Air & Space

National Air & Space Museum
Smithsonian Institution

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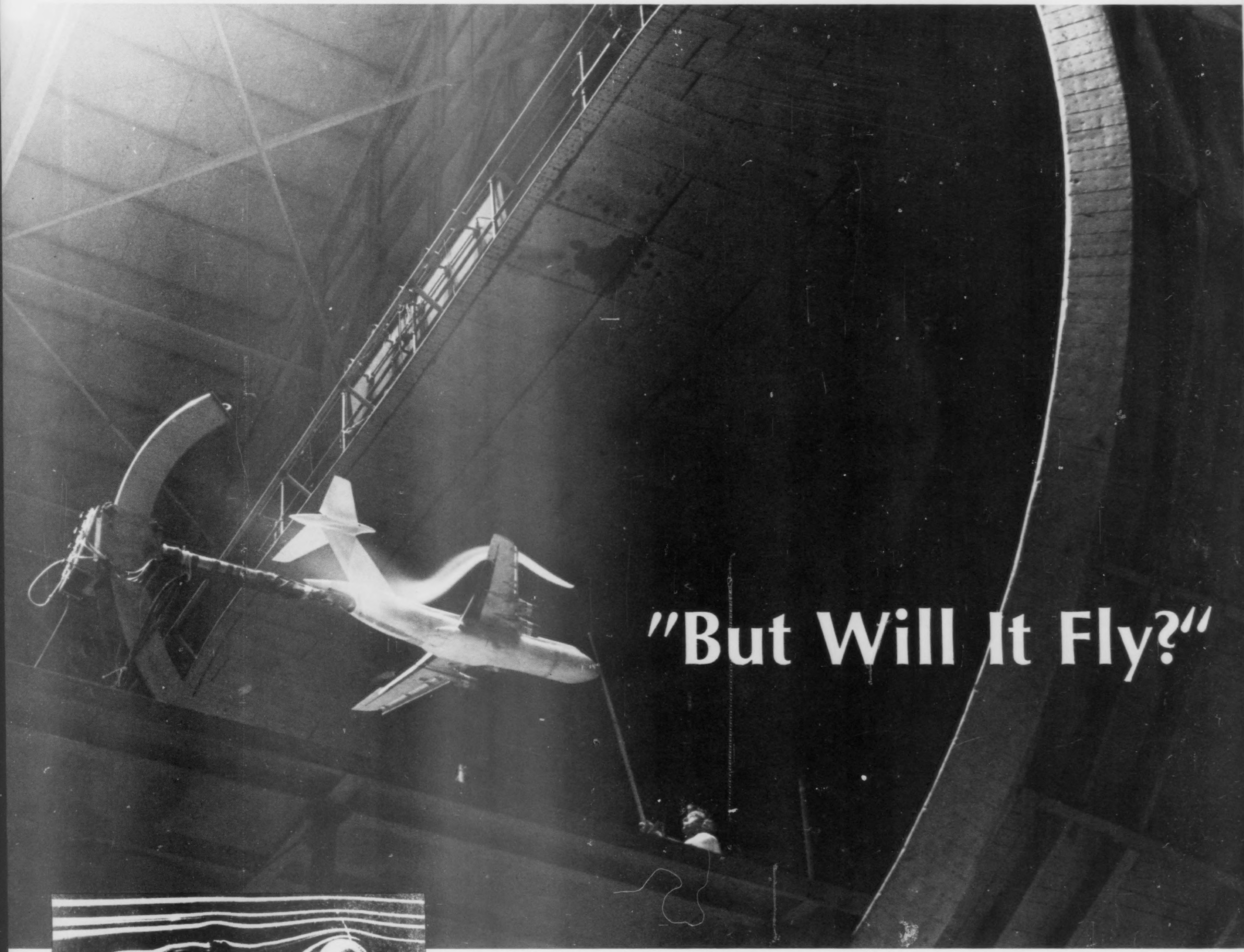
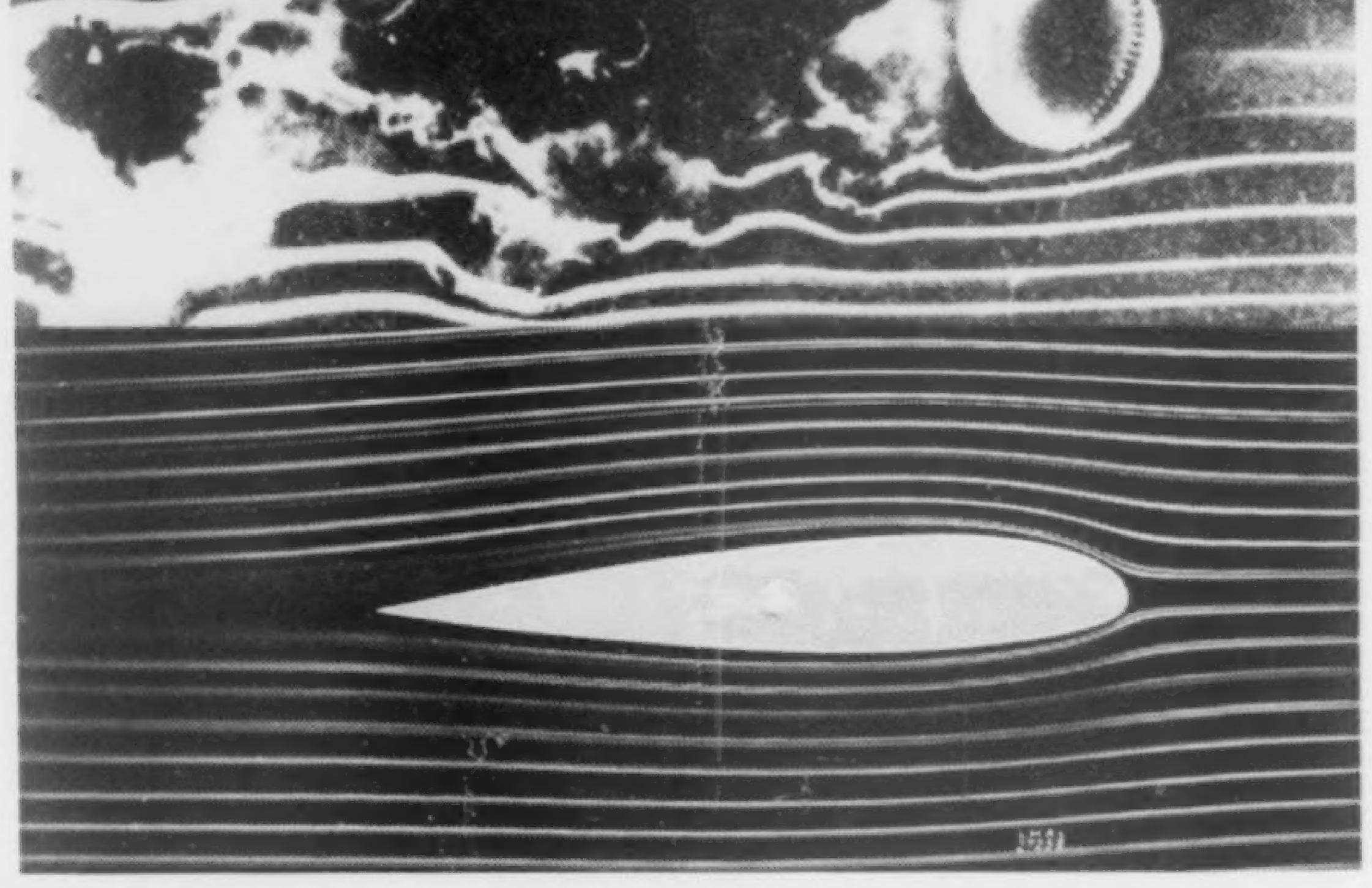


"But Will It Fly?"

Yes, the jet of smoke blown over a scale model of a plane in a wind tunnel, above, indicates that the wing is lifting. There is an upward movement of the smoke line ahead of the wing (upwash) and a downward movement of the smoke line behind the wing (downwash). One way to state Newton's Second Law is that force is proportional to the rate of change of momentum; hence, the smoke line shows conclusively that there is an upward or lift force on the wing. Many factors of flight are studied in wind tunnels at great savings of time, cost and fuel. More, Page 3.



Baseball in a wind tunnel. Airfoil in a non-lifting position; jets of wind tunnel smoke show the same flow and pressures on both sides.

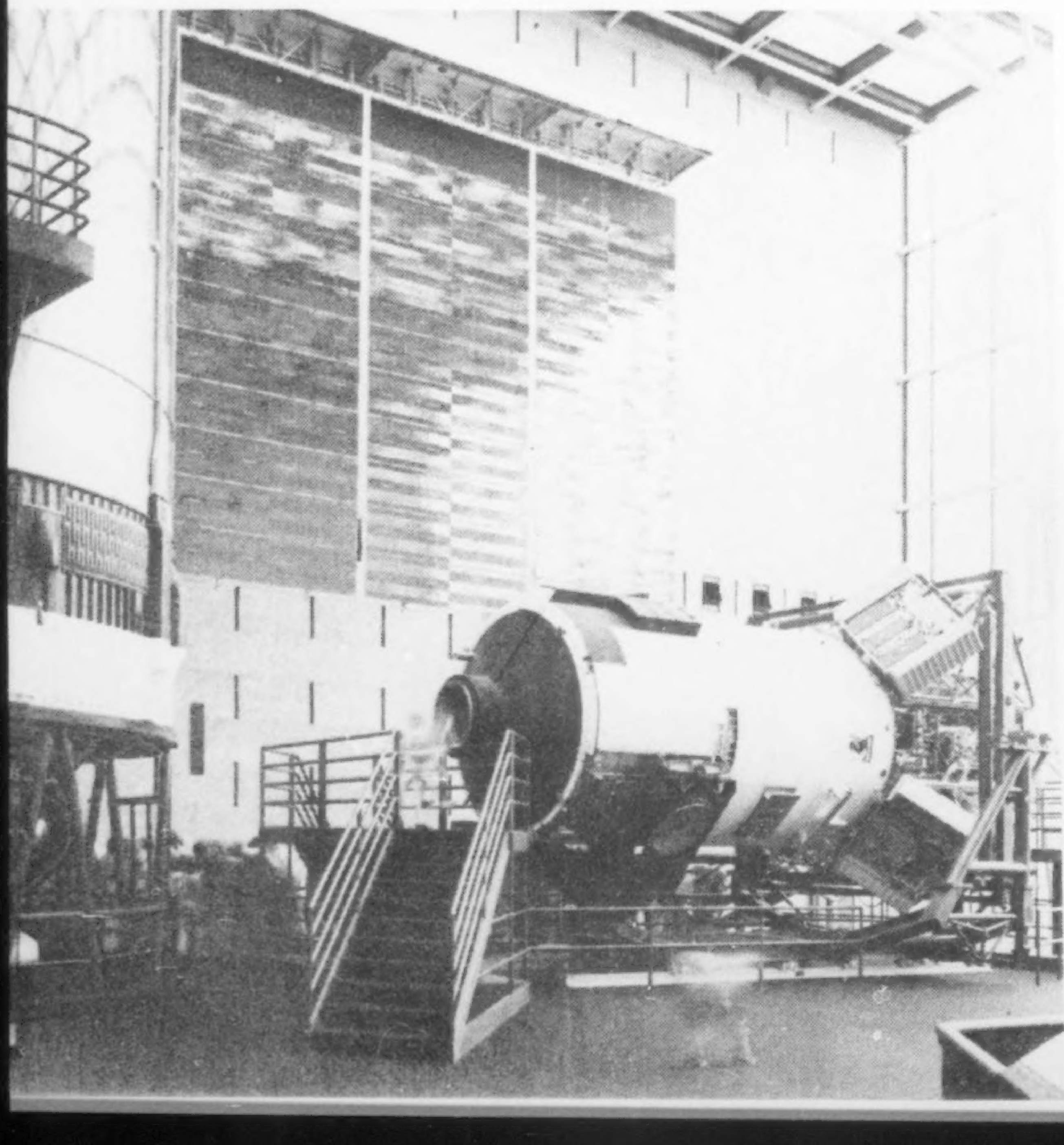
INSIDE: Wind tunnel to build, Page 6. "Spirit of St. Louis" plans, Pages 8-9. Solar System, Page 10. Sky map, Page 14.

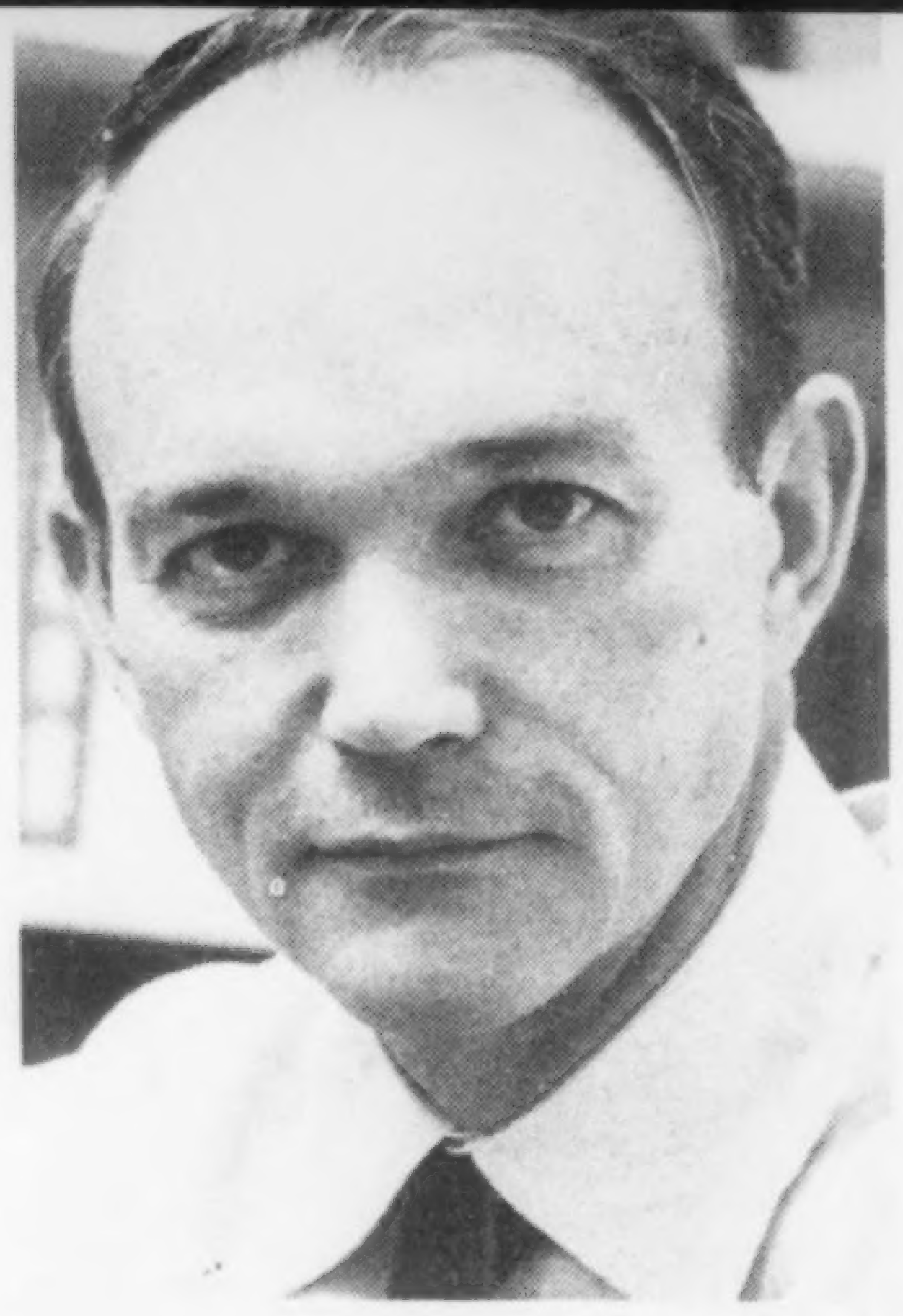
Skylab Under Control

News stories last February publicized Skylab's deteriorating orbit, and fear that the 85-ton laboratory might make an uncontrolled return to Earth. The breakup of a Soviet nuclear-powered satellite over Canada had just illustrated the hazard.

Photographs above and below show the backup Skylab on display at the National Air and Space Museum. At lower right is a drawing of the assembly in space. Launched in 1973, Skylab was occupied by three different crews performing scientific experiments in weightlessness. It has been unused since February, 1974.

In March, NASA controllers found that communications links still work. They ordered batteries recharged with power from the solar cells (the large, dark panel). Now they may maneuver to delay Skylab's reentry until one of the first Shuttle flights can rendezvous and either boost it to a safe orbit, or direct it to a controlled, ocean-targeted reentry.





Briefing From the Director

Michael Collins

May is a lovely month in Washington. Winter is almost forgotten, as long days and balmy nights replace memories of slippery, potholed roads and icebound rivers. June's star chart (Page 14), will, I hope, entice some of you outside at night for a little stargazing.

I was over 30 years old when I took my first astronomy lesson, and I have always regretted that I didn't get started earlier. For me, that first lesson was like eating the first peanut. All my life, I had gotten along just fine without the stars and planets, but once I began to learn a little about them, I became intrigued and craved more. Perhaps my enthusiasm could be traced to the fact that I was expected to be able to navigate to the Moon and back using the stars.

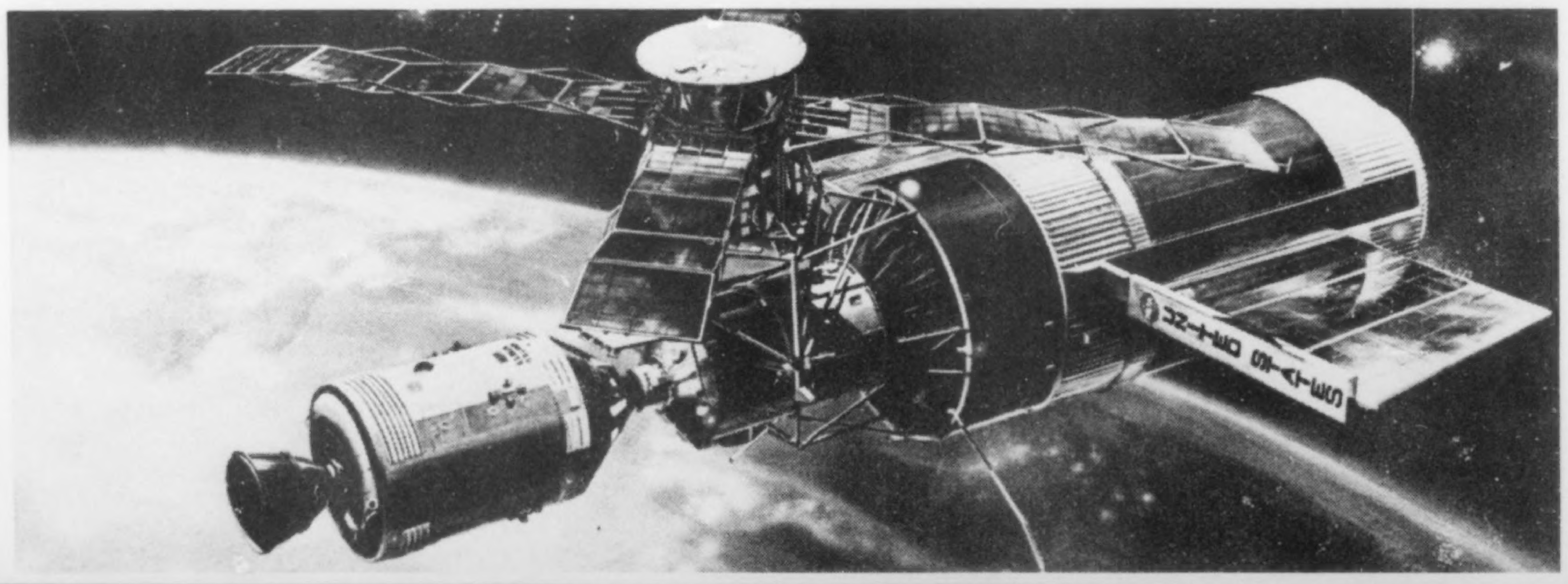
Perhaps even more fascinating than the stars are the planets. Venus, for example, is (with the exception of the Sun and the Moon) the brightest object in the sky. It's so bright, in fact, that even experienced astronauts have mistaken it for a UFO. The article in this issue, "Earth's Family—Children of the Sun, the Solar System," puts Venus in a clearer perspective relative to the other planets: Mercury, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto. Even the names are intriguing—these are places I'd like to visit.

We can learn more about the earth by comparing it with the other planets. On a larger scale, we can learn by comparing our Sun with other suns, our galaxy with other galaxies. How did it all start? Where is the universe going? It is expanding, we know, but will it continue to do so, or will it reverse the process, and implode into itself? This is perhaps the most fundamental question facing astronomers today.

At the Smithsonian's Center for Astrophysics, recent discoveries of gigantic clouds of hot gases between galaxies would seem to indicate that there may be sufficient matter in the universe for a reversal to take place. In other words, gravitational forces could be strong enough to slow down, and eventually reverse, the expansion of the universe—so that it will collapse back upon itself once more. But don't be too alarmed. If it happens, it won't be for another 80 billion years!

Recently I finished a fascinating book, "Autobiography of Values," a posthumous publication of Charles A. Lindbergh's story of his own life. I think Mr. Lindbergh would have felt a special kinship with the astronomers who are wrestling with this problem of the universe's destiny. His book ends with this description of his own destiny. "After my death, the molecules of my being will return to the earth and the sky. They came from the stars. I am of the stars."

As for me, I just wish I'd started studying astronomy earlier.

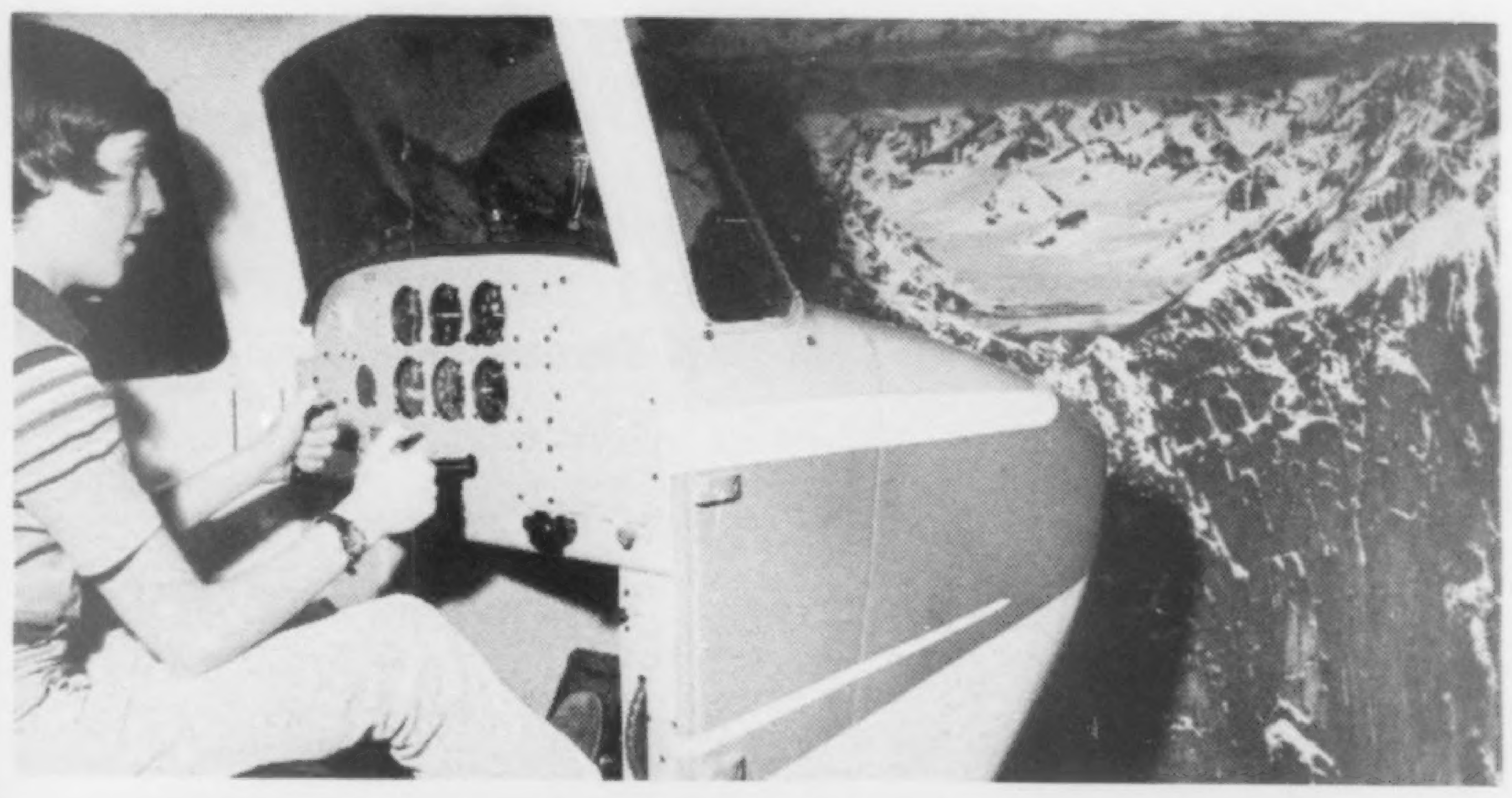


GROUND TESTING

Comparatively inexpensive, fuel-saving ways to simulate flight

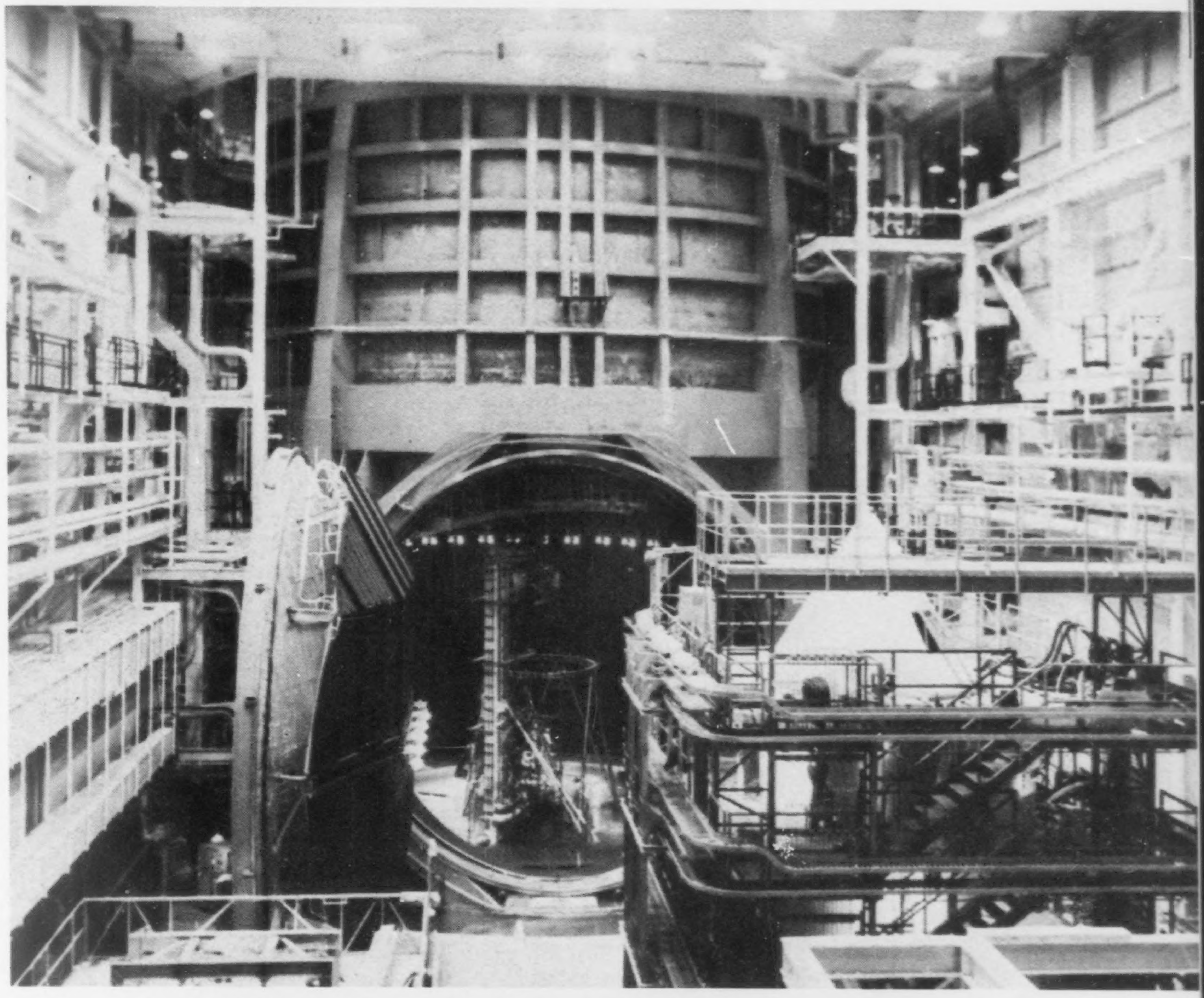
for pilots

General Aviation Trainer (GAT-1) "flown" by visitors at the National Air and Space Museum. Second below: Space Shuttle Orbiter flight deck simulator, with astronaut-pilot Fred W. Haise, Jr.



for vehicles

Test chamber, Johnson Space Center, where spacecraft are subjected to the vacuum and temperatures of space. Next below: Dr. Richard T. Whitcomb, noted aerodynamicist, in a wind tunnel at Langley Research Center. Bottom: Jets of fog show airflow in a McDonnell Douglas wind tunnel.

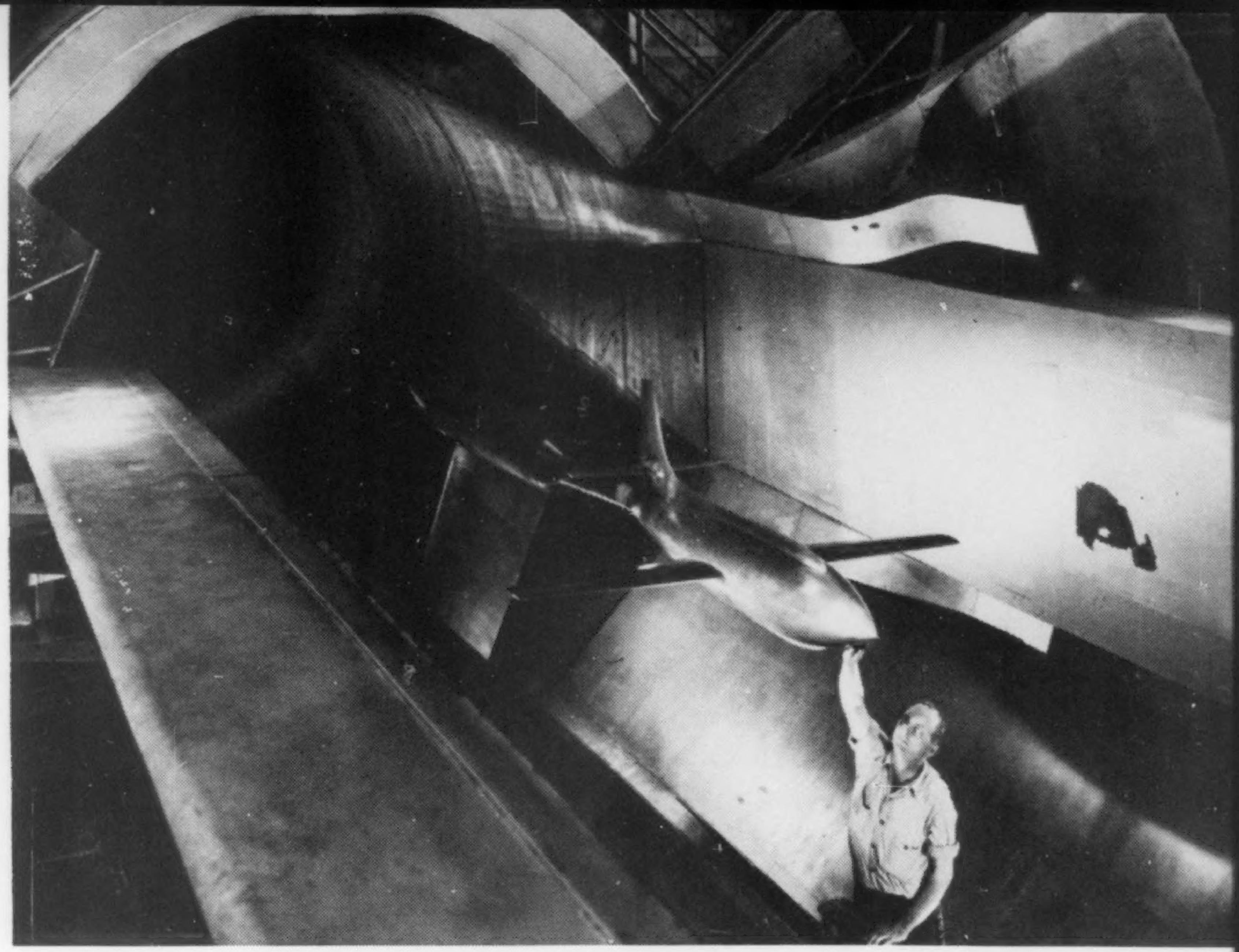


Wind Tunnels

In the development of new aircraft, designers and engineers draw on a store of knowledge: well-understood principles, time-tested equations, and accumulated data. These are all reflected in the design calculations of the airplane. However, no amount of calculations can replace actual testing. Aerodynamic testing is frequently performed in a wind tunnel. A wind tunnel is a machine which can pump air over a range of speeds while the effects of the pumped air stream on a model are measured. Today, according to Leonard E. Stitt at NASA's Lewis Research Center, there are more than 1,000 wind tunnels throughout the world, about 250 in the U.S. They may be small, or as large as the one shown on the cover; they offer variable air density, subsonic or supersonic air speeds, and have computerized controls and data systems that look like something out of *Star Trek*.

Continued on the next page

Many teachers begin units on flight by providing feathers, styrofoam, paper or balsa, and asking students to create objects that will fly— say across a desk. Why do some make it, and others fail? If a school's Industrial Arts students will build the small wind tunnel sketched on Page 6, students can make airfoils to fit, and see what happens during flight.



A technician positions a quarter-scale model of the X-1 research plane in the slotted throat test section of the 16-foot transonic wind tunnel at Langley Research Center.

WIND TUNNELS—

Continued from Page 3

The main forces involved in flight are weight, lift, drag and thrust. For sustained flight, all must be in equilibrium. Lift and drag are aerodynamic forces which can be studied in wind tunnels.

The Museum's assistant director for science and technology, Dr. Howard S. Wolko, has stories, such as the following, about early tunnels.

When Orville and Wilbur Wright's 1901 glider failed to come up to expectations, the two pioneers built a small wind tunnel with sensitive balances to measure forces on the wings. Within a year, the experiments showed them what to do. A new wing design proved successful on a glider, flown in 1902. Then they attacked the problems of powered flight with confidence, and made the first successful demonstration in December of 1903.

Early planes were built "by guess and by gosh." The Europeans had research agencies that used wind tunnels before the U.S. which finally organized the National Advisory Committee for Aeronautics (NACA) in 1915. (In 1958, this agency became the National Aeronautics and Space Administration, NASA.)

At first, engineers knew that analyses on models in wind tunnels did not quite match the results secured in actual flight of the comparable full size aircraft, that is, the data did not "scale."

Max Munk at Langley Research Center, Hampton, Virginia, reasoned that there could be a relationship between the size of a model and the density of the airflow in which it was tested; that is, if a model 1/20th the size of the proposed aircraft were tested in airflow 20 times normal density, the test measurements should be realistic. When NACA completed the first Variable Density Wind Tunnel in 1923, the theory was proved correct.

Other Museum staff members talked of the major hurdle of the 1940's, the design of a tunnel for supersonic airflow. Tunnels "choked" at transonic velocities. The solution was to expand the flow by using a "slotted throat" (a special kind of test section) to increase the flow area beside and downstream of the model (see photograph above).

In general, wind tunnels can be either open circuit, or closed circuit, as diagrammed on Page 5.

The open circuit is the simpler type. The motor and propeller suck air into the inlet. After the inlet, turbulence must be reduced. The flow is smoothed by screens and other devices before the air is accelerated through a nozzle to the test section. After the test section, a diffuser causes the air to lose its speed and come back to room pressure for higher efficiency. The contouring of both the contraction zone, or nozzle, and the diffuser must be precise.

CLASSIFICATION OF WIND TUNNELS ACCORDING TO THE SPEED OF AIRFLOW IN THE TEST SECTION

Tunnel class	Free-stream Mach-number[a] range
Low speed	0 to 0.5
High speed	0.5 to 0.9
Transonic	0.7 to 1.4
Supersonic	1.4 to 5.0
Hypersonic	>5.0

[a] $\text{Mach number} = \frac{\text{Local stream velocity}}{\text{Local velocity of sound}}$

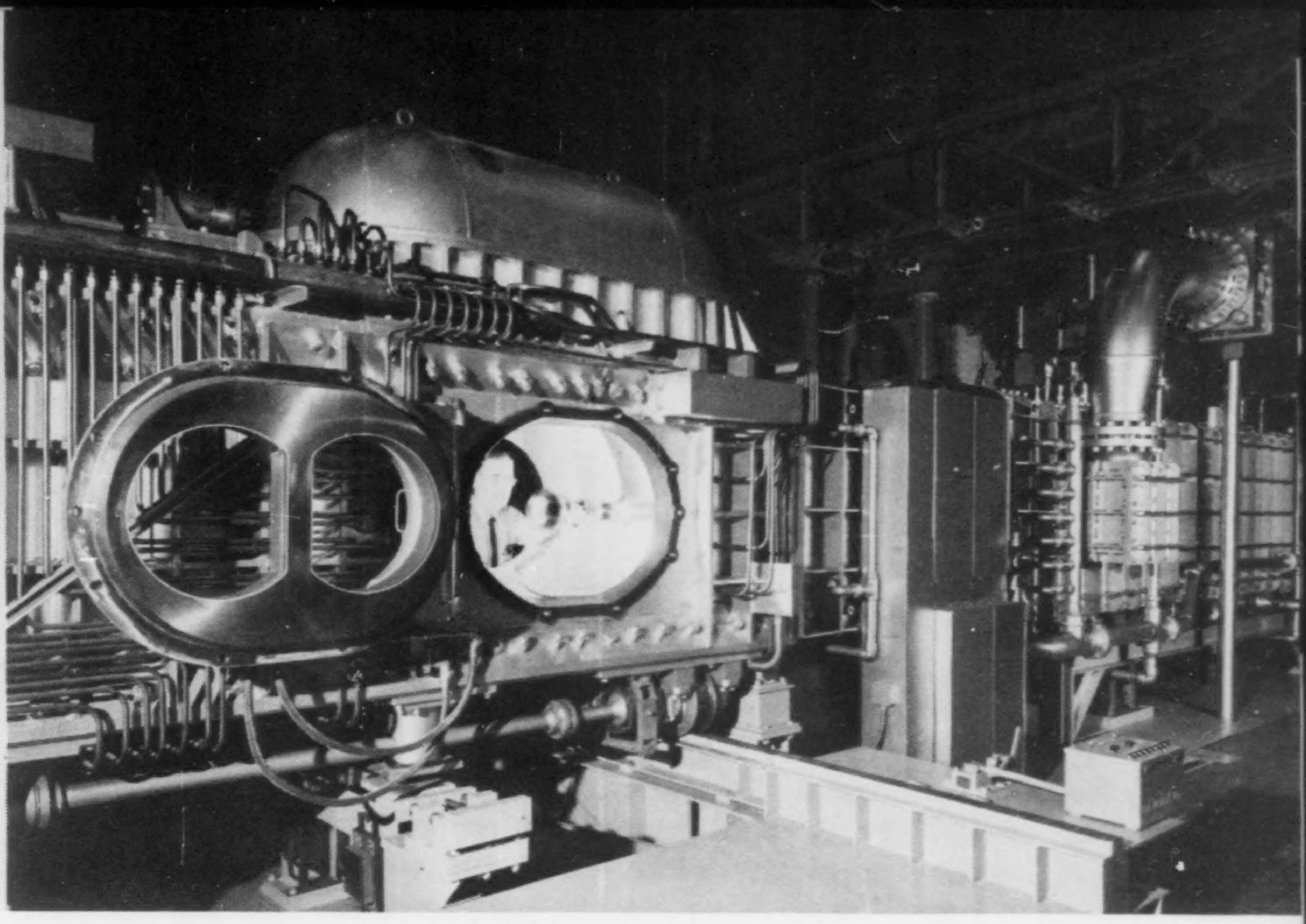
The wind tunnel test section is frequently windowed and sometimes illuminated, as in the tunnel pictured top right, opposite page.

The closed circuit wind tunnel requires more space and is more expensive, but more efficient in the use of power. The diagram shows not only elements named in the open circuit layout but in addition, passages for recirculating the air.

Test sections vary widely. When they lack walls, they are called "open throat," as the Langley tunnel shown on the cover. In the lower photograph to the right, the model is not mounted in the test section. Why? Let students send their explanations to *Air & Space*. Names of the ones giving correct answers will be published next fall.

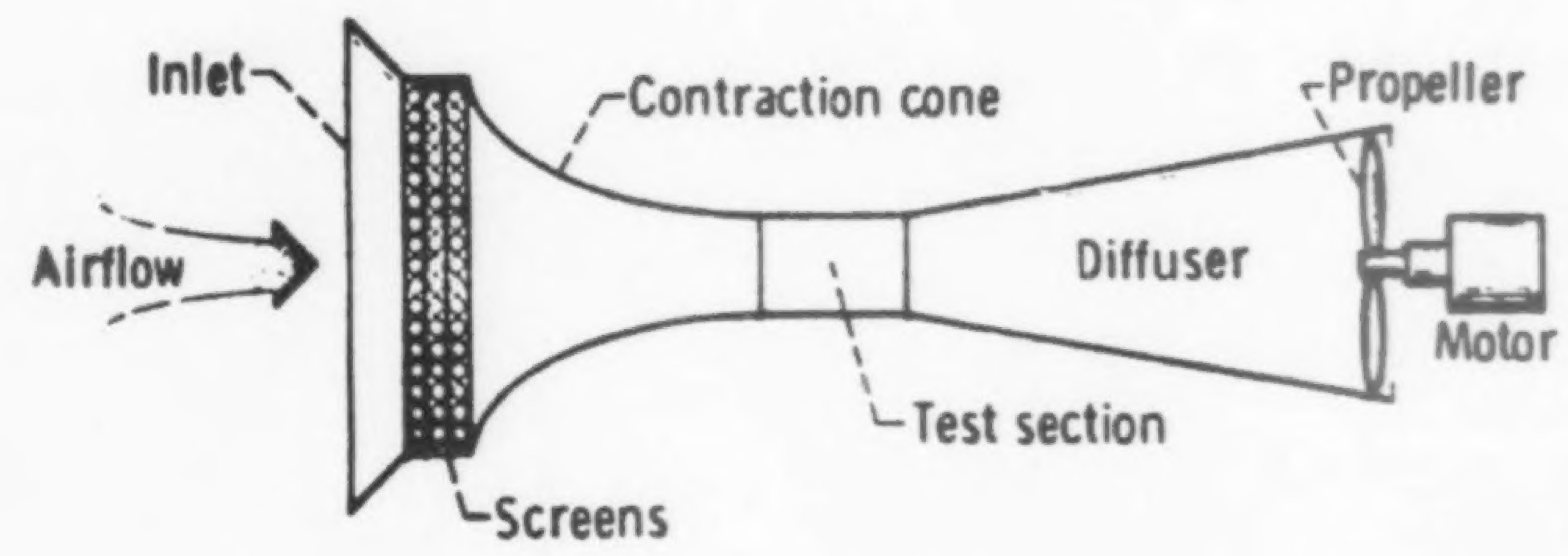
That model is on a "sting mount" which carries a mass of wiring from sensors. Many different devices are used to mount models. Sometimes these support systems can interfere with measurements and results have to be appropriately corrected.

Teachers and students may send in questions about wind tunnels which will be answered in a future issue or in a special publication.

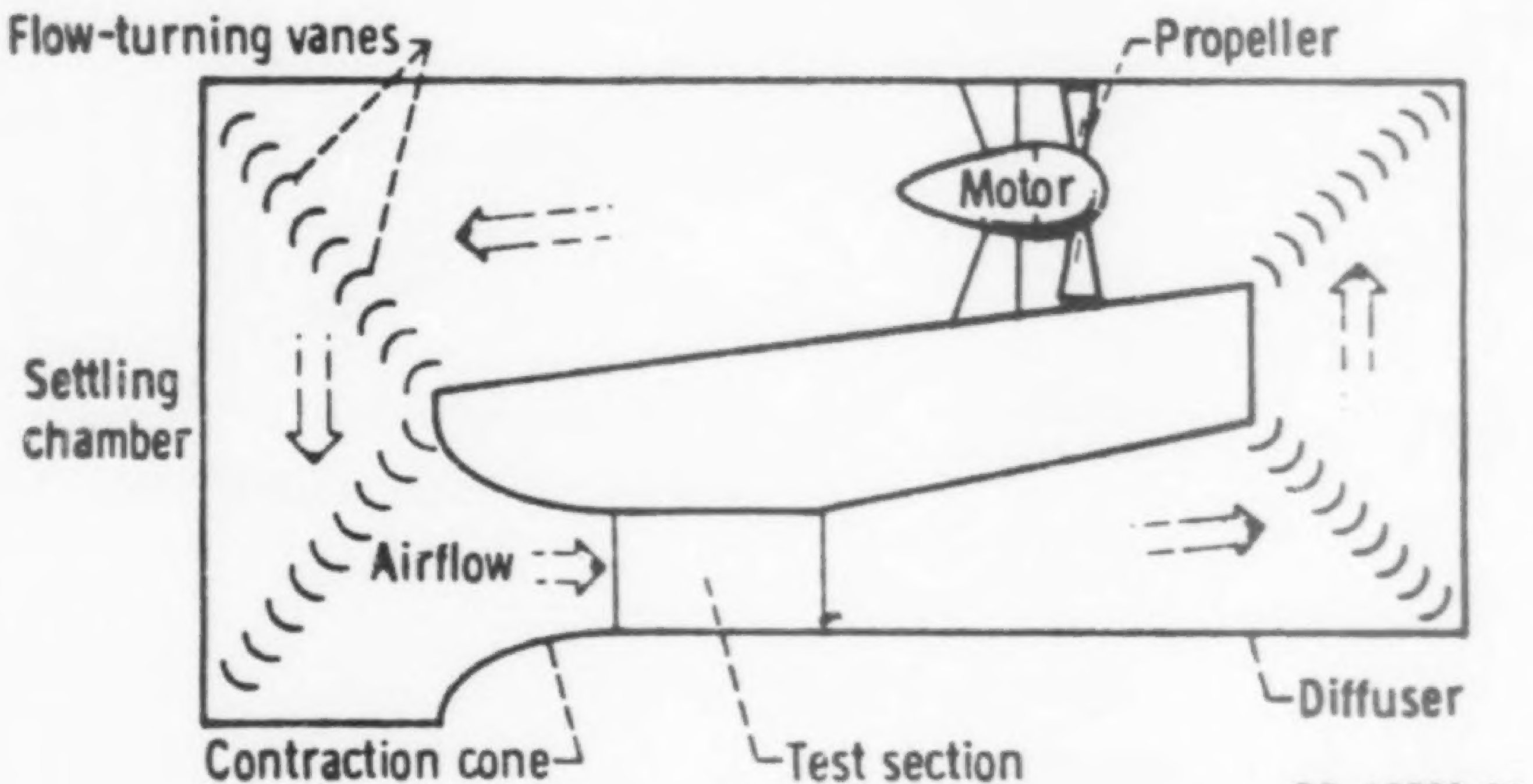


Above left, the motor and propeller in a wind tunnel designed for current testing of V/STOLs, vertical and short takeoff and landing craft. Above, a calibration model on a sting support is being placed in the test section of Langley's continuous flow hypersonic wind tunnel; air speed reaches Mach 10. Below, model of the XC142 V/STOL turboprop aircraft undergoing attitude testing in a Vought Corporation low speed wind tunnel.

OPEN CIRCUIT WIND TUNNEL



CLOSED CIRCUIT WIND TUNNEL



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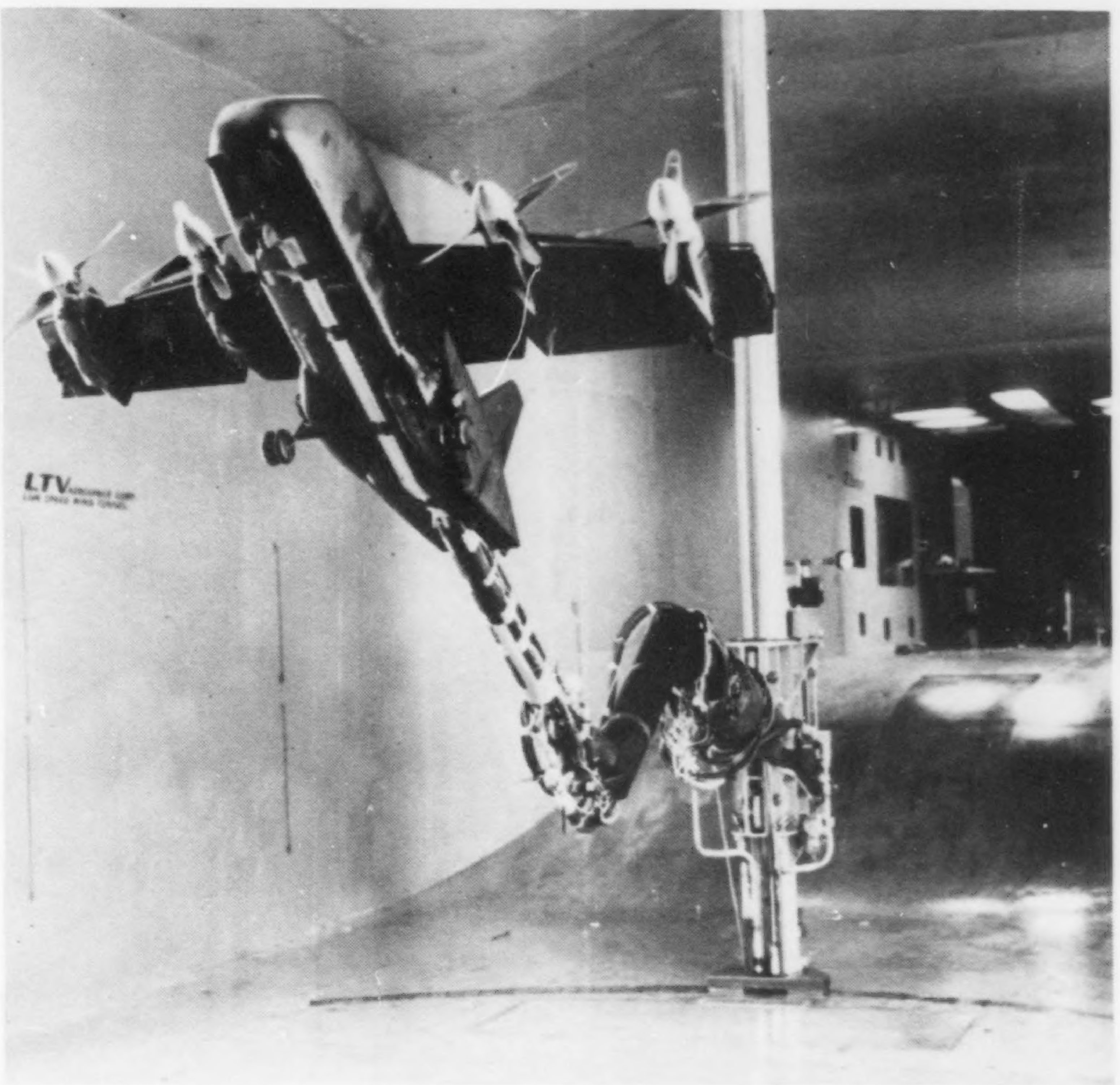


Readings in Aerodynamics

Introduction to the Aerodynamics of Flight, Theodore A. Talay, Langley Research Center, paperback, 8 by 10½ in., 198 pp., technical diagrams and formulas, bibliography. NASA SP-367, 1975. National Technical Information Service, Springfield, Virginia 22161. Order No. N76-11043/LLC, $9.25.

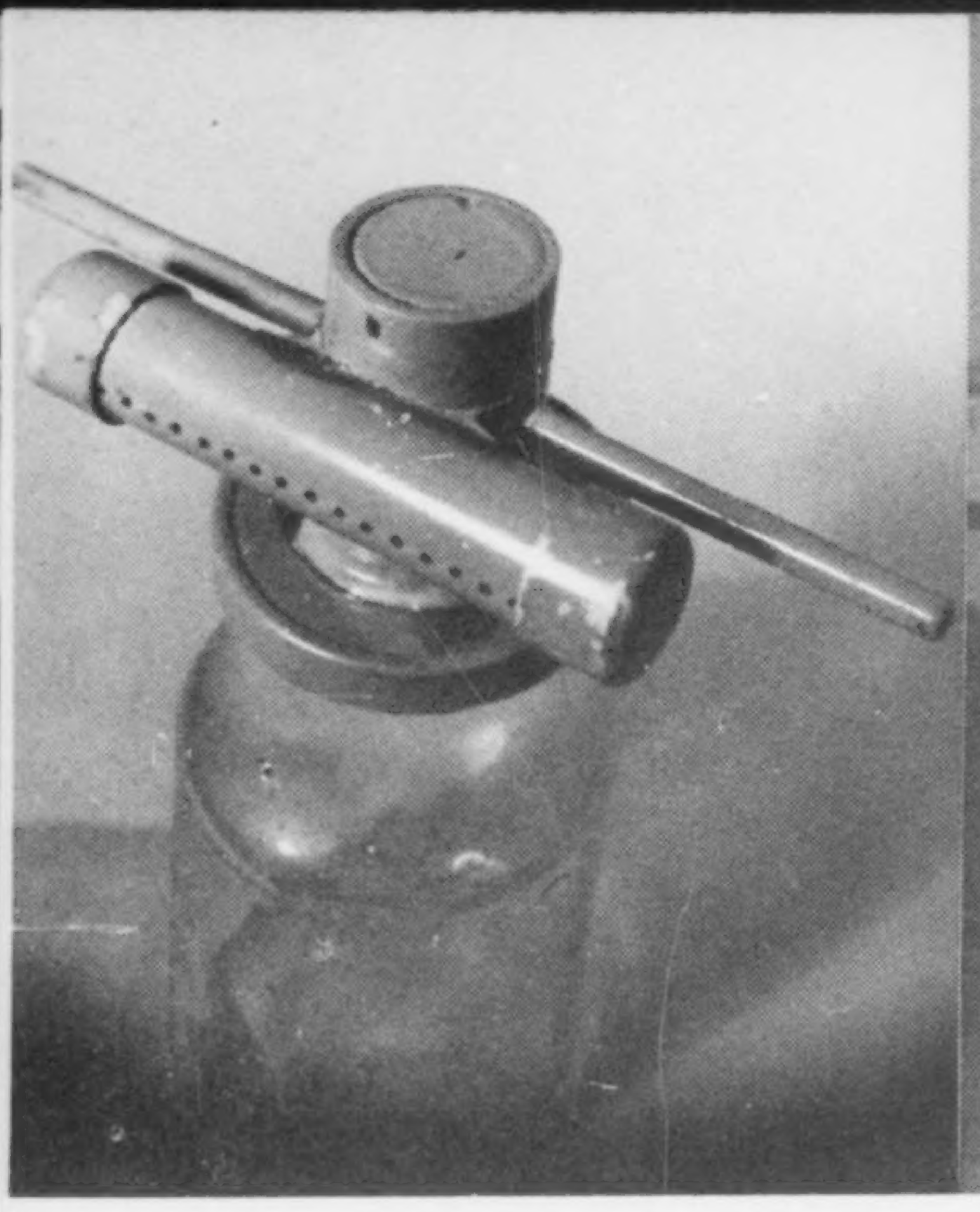
Flight, H. Guyford Stever and James J. Haggerty, 200 pp., illus., colorful diagrams in popular text. Life Science Library, Time, Inc., 1969, $7.95 in stores, $5.95 from Time-Life Books, 541 N. Fairbanks Court, Chicago, Illinois 60611.

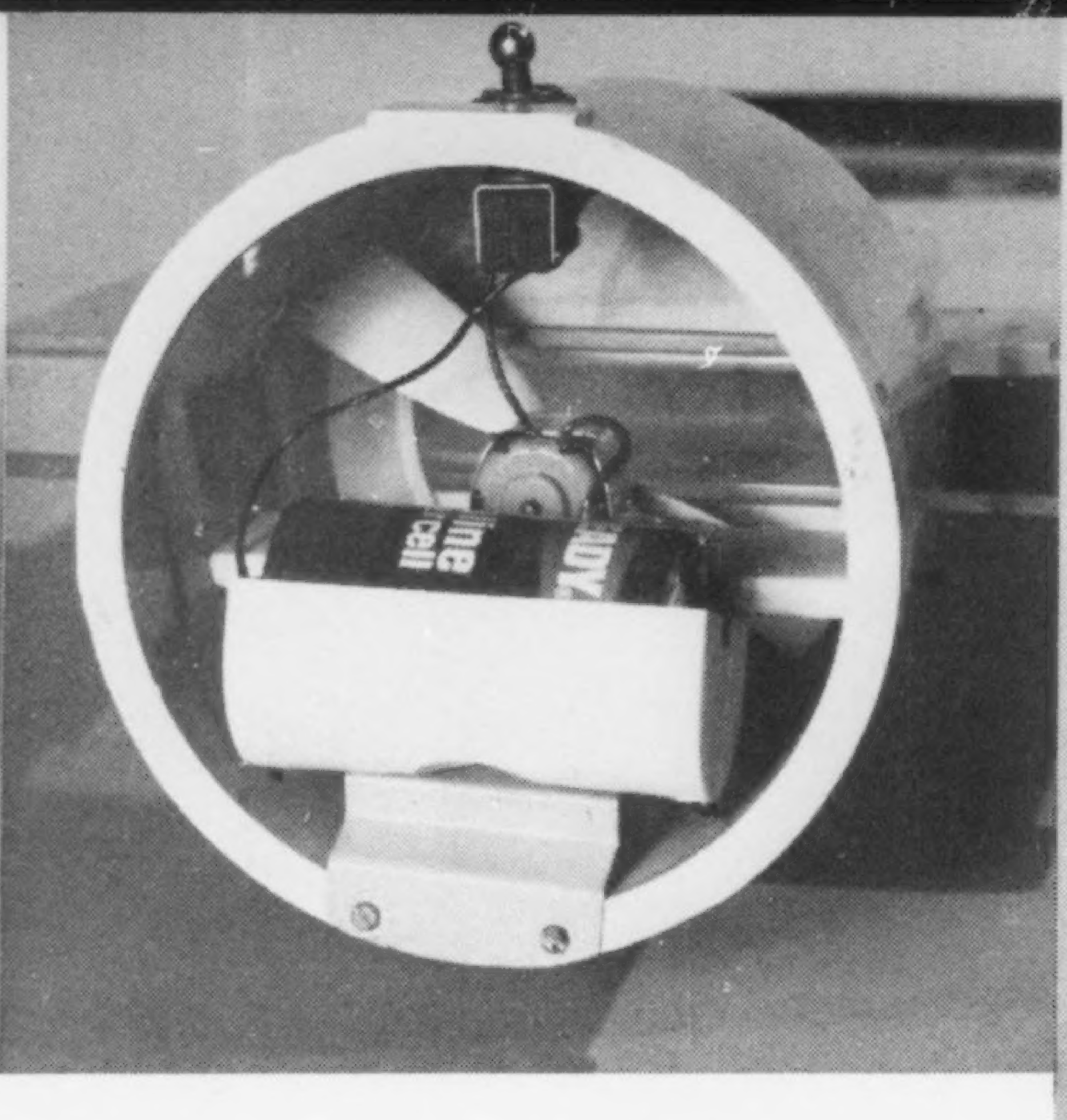
Building a Wind Tunnel, Technical Report 5, Estes Industries, Inc., 7 pp., working drawings for small structure with ⅙ to ½ hp motor and "squirrel-cage" blower. Estes, Box 227, Penrose, Colorado 81240.

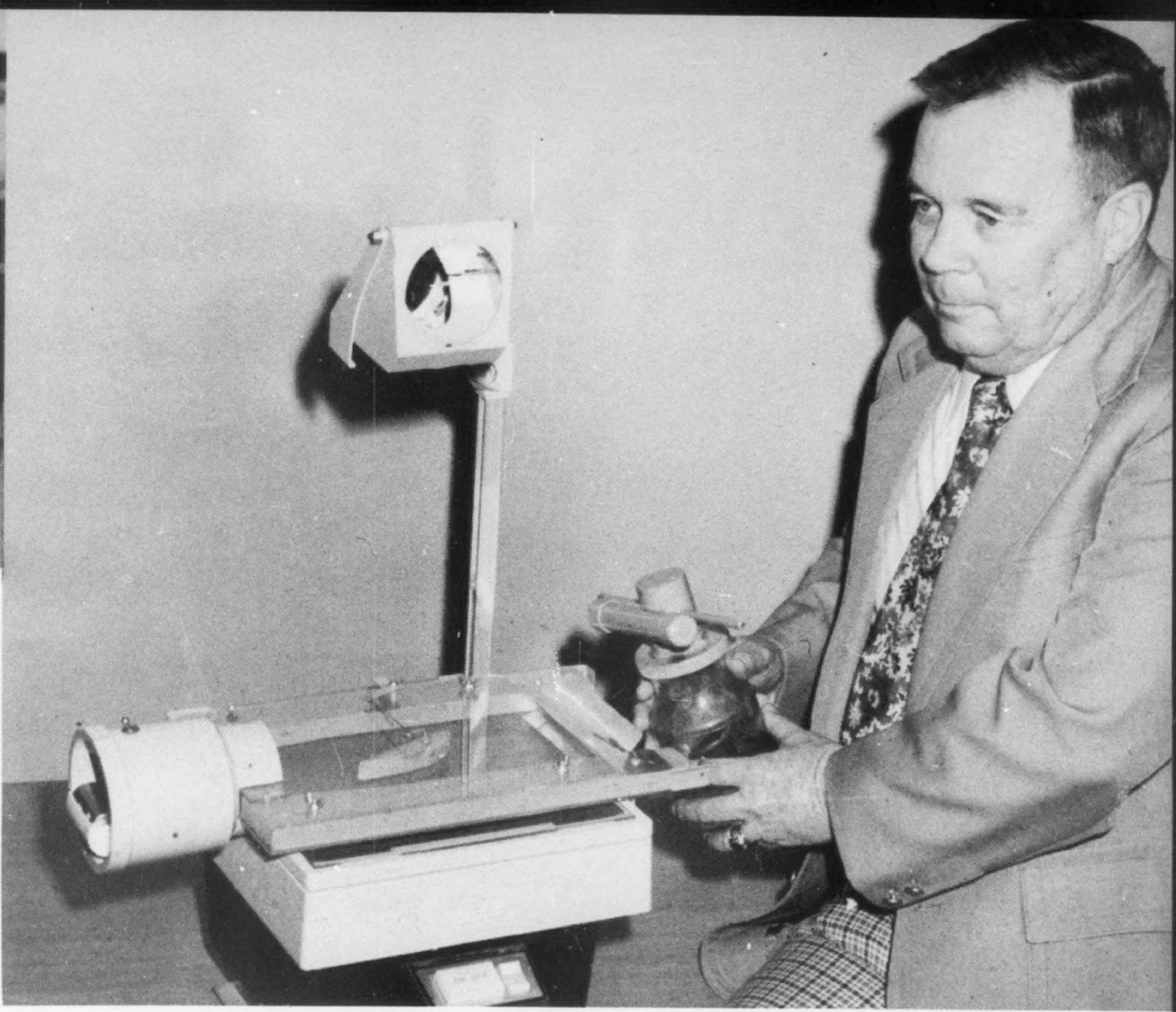
"How to Build a Wind Tunnel that Achieves Supersonic Speeds with a Vacuum System," *Scientific American,* April 1972. By a high school student whose device won four awards at a science fair. Construction details for other small wind tunnels in *Scientific American* of April 1953 and May 1955.

"Mach 3 for $2.99" by George M. Pantalos, then an Ohio State University engineering student, *AIAA Student Journal,* Summer 1976. $5 from American Institute of Aeronautics and Astronautics, 1290 Avenue of the Americas, New York, NY 10019.

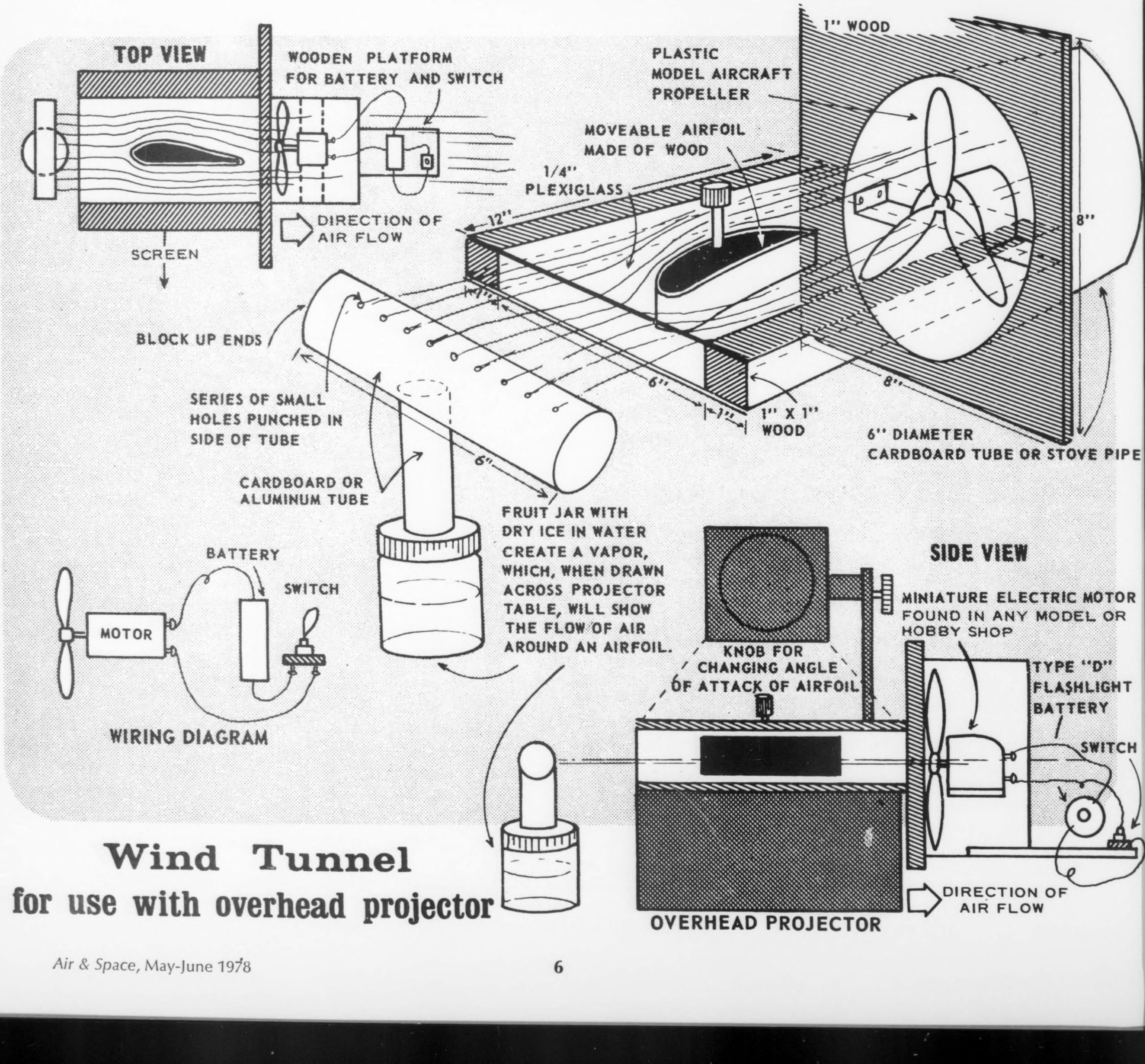
Fundamentals of Aviation and Space Technology, Institute of Aviation, University of Illinois, Roger E. Bilstein, Ed.; paperback, 8 by 11 in., 249 pp., illus., glossary, index. Order from the University's Institute at Willard Airport, Savoy, Illinois 61874, $3.50.





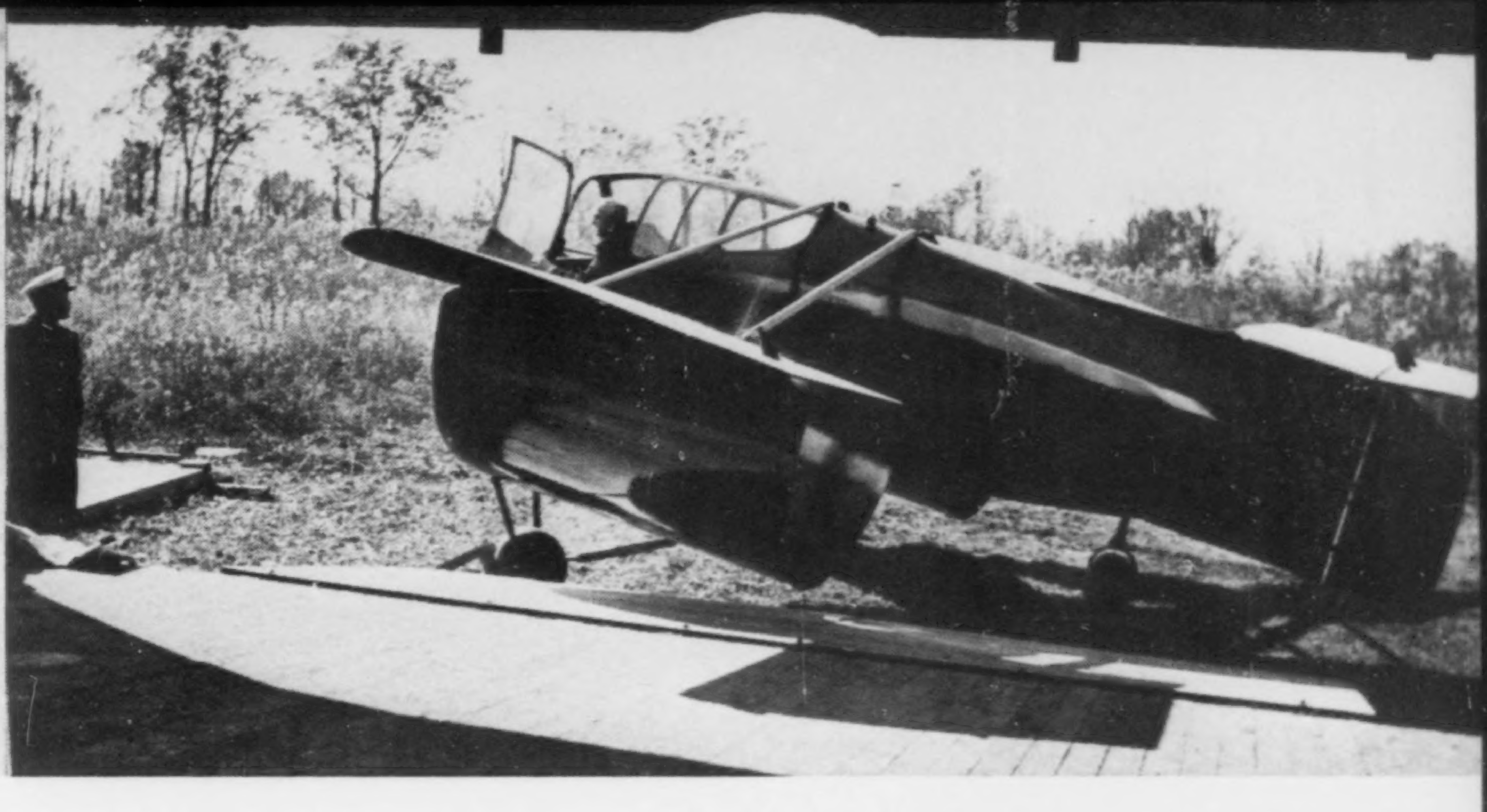


At right, William J. Reynolds, the CAP Middle East Region Aerospace Education Director, demonstrates his design for a wind tunnel which students could build from the plans below. A model airfoil can be variously positioned between two glass plates. Dry ice is thrown into warm water in the jar at one end; fumes are drawn through the "tunnel" by the small, battery-powered fan at the other end. The device fits the table of an overhead projector for dramatic enlargement of the airflow pattern over the model.


TOP VIEW
WOODEN PLATFORM FOR BATTERY AND SWITCH
DIRECTION OF AIR FLOW
SCREEN
1" WOOD
PLASTIC MODEL AIRCRAFT PROPELLER
MOVEABLE AIRFOIL MADE OF WOOD
1/4" PLEXIGLASS
12"
8"
BLOCK UP ENDS
1"
6"
8"
1"
1" X 1" WOOD
6" DIAMETER CARDBOARD TUBE OR STOVE PIPE
SERIES OF SMALL HOLES PUNCHED IN SIDE OF TUBE
6"
CARDBOARD OR ALUMINUM TUBE
FRUIT JAR WITH DRY ICE IN WATER CREATE A VAPOR, WHICH, WHEN DRAWN ACROSS PROJECTOR TABLE, WILL SHOW THE FLOW OF AIR AROUND AN AIRFOIL.
BATTERY
SWITCH
MOTOR
WIRING DIAGRAM
SIDE VIEW
MINIATURE ELECTRIC MOTOR FOUND IN ANY MODEL OR HOBBY SHOP
KNOB FOR CHANGING ANGLE OF ATTACK OF AIRFOIL
TYPE "D" FLASHLIGHT BATTERY
SWITCH
DIRECTION OF AIR FLOW
OVERHEAD PROJECTOR

Wind Tunnel
for use with overhead projector

BOEING 707



CUSTER CHANNEL WING

FAMOUS AND OBSCURE PLANES, NO. 3

by Walter J. Boyne
Curator of Aeronautics
National Air and Space Museum

THE BOEING 707

Throughout its history, the Boeing Company has characteristically created outstanding new prototypes, and then courageously backed their development with every dollar of the company's resources. The gambles paid off with the B-17, the 727, and the huge 747, but never more so than with the historic 707, the first U.S. commercial jet liner.

The prototype Model 367-80 made its first flight on July 15, 1944, and started an air transportation revolution. Cruising 250 mph faster than current piston engine transports, and 100 mph faster even than the unlucky British de Havilland Comet, the world's first jet liner, the 707, was soon ordered by every major airline.

The prototype, affectionately called "Dash-80" by Boeing engineers, was never intended to enter air line service after testing. Instead it served Boeing as a test vehicle for many years, undergoing numerous engine and aerodynamic changes that paved the way for many later aircraft including the famous KC-135 tankers, and the 727 and 737 transports. At one time it was flown with three different types of engines installed, and on another was actually fitted with a fifth engine.

Since the advent of the 707, Boeing has built more than 3,045 jet transports, all of which bear a close family resemblance to their illustrious predecessor. The Dash-80 now belongs to NASM, and is in storage at Tucson, Arizona.

THE CUSTER CHANNEL WING

This craft is in its way as much of an American saga as the 707, for it represents the 50 year battle of a man for his ideas. Willard R. Custer is the prototype Yankee inventor—smart, tough, resourceful and unafraid of the machinations of big government or big business.

Since 1929, Custer has advocated aircraft wings fitted with huge semi-circular channels, through which air is sucked, and by which direct lift is created via the Bernoulli principle. Custer claims a great advantage in lift, and hence efficiency, and maintains that the Channel Wing can do many things better than either a conventional aircraft or a helicopter can do them.

Custer's statements have been challenged over the years by engineers who argue that the advantages gained at the low end of the speed range are offset by disadvantages at the high end. Still, after 50 years, the controversy goes on.

The first full size Custer Channel Wing flew in 1942, and since then there have been three other full size aircraft. Production seemed imminent on several occasions, but difficulties always intervened. There has recently been a revival of interest in the concept, particularly in regard to the scope of its patent coverage.

The original Custer Channel wing is on exhibit at NASM's Silver Hill facility.

Another Wright Flyer

A painstakingly accurate reproduction of the Wright brothers' "Kitty Hawk Flyer" takes shape as a project of three students, left to right below, Campbell Shannon, Ted Walsh and Ben Curran. They attend Pingree High School, South Hamilton, Massachusetts. As anyone may, they bought copies of working drawings from the National Air and Space Museum where the original 1903 Flyer is exhibited. Several museums are interested in buying the duplicate.

PLANS

for

LINDBERGH'S

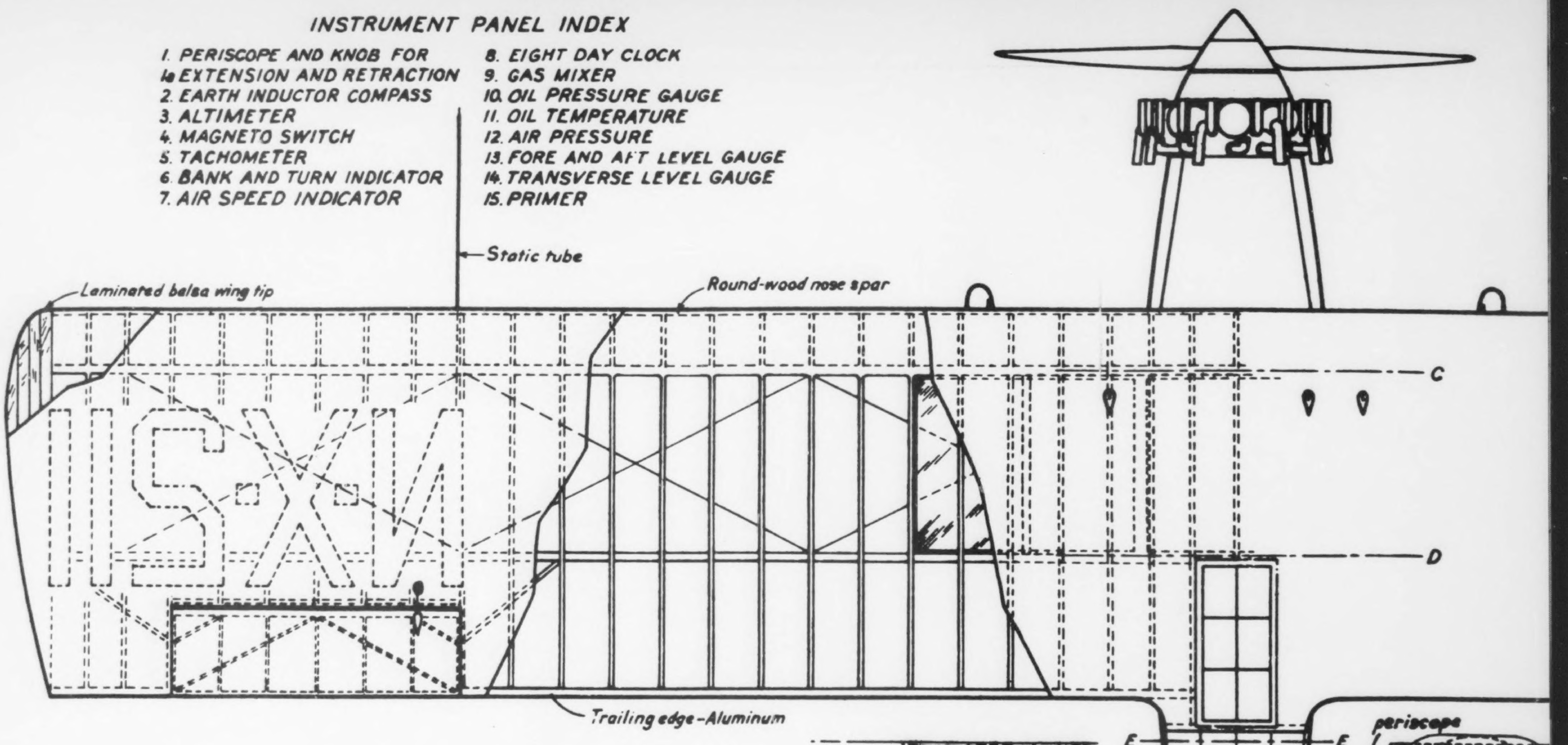
"The Spirit of

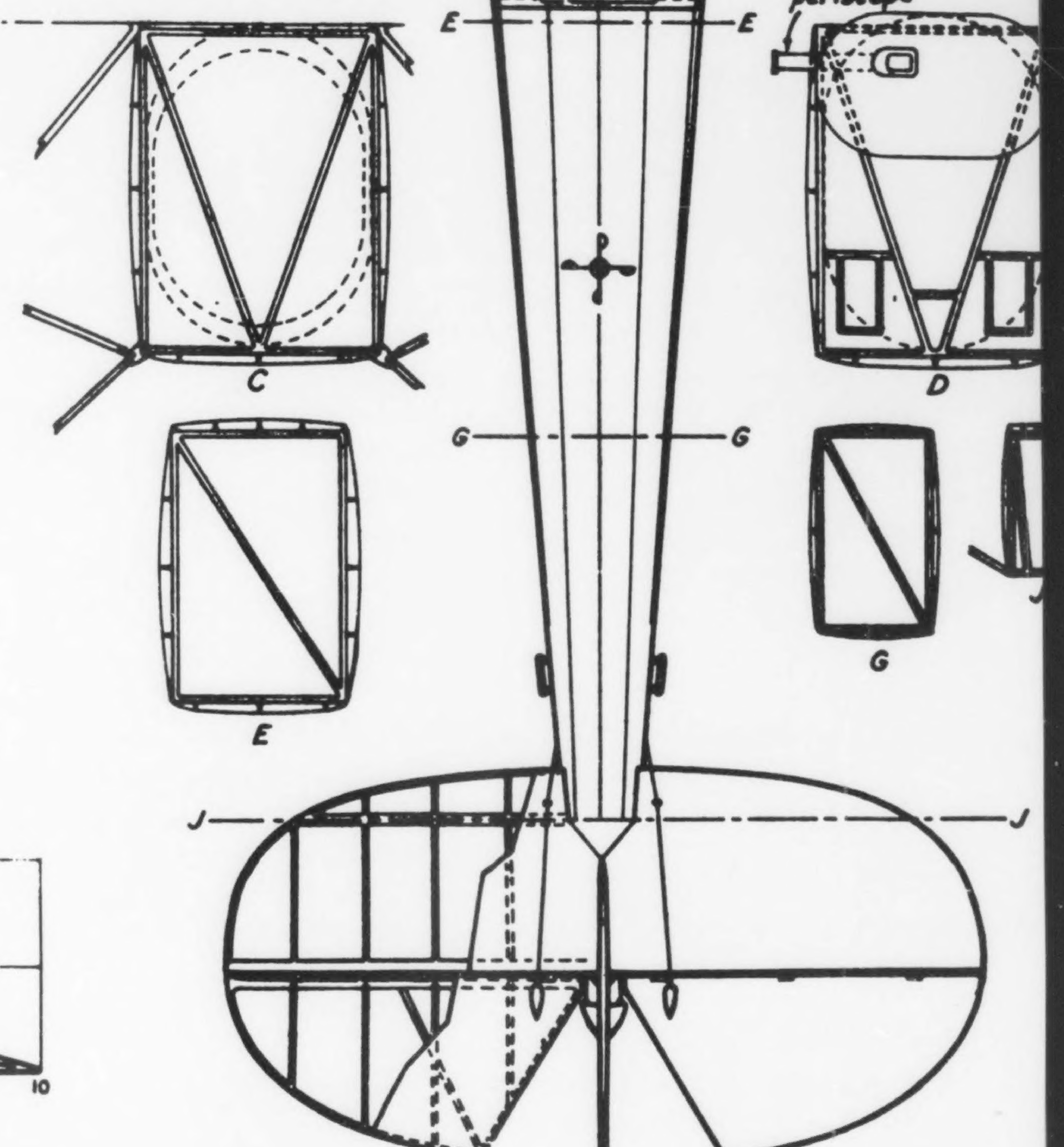
St. Louis"

as requested by
Joseph H. Miller
James Buchanan High School
Mercersburg, Pennsylvania

INSTRUMENT PANEL INDEX

1. PERISCOPE AND KNOB FOR
1a EXTENSION AND RETRACTION
2. EARTH INDUCTOR COMPASS
3. ALTIMETER
4. MAGNETO SWITCH
5. TACHOMETER
6. BANK AND TURN INDICATOR
7. AIR SPEED INDICATOR
8. EIGHT DAY CLOCK
9. GAS MIXER
10. OIL PRESSURE GAUGE
11. OIL TEMPERATURE
12. AIR PRESSURE
13. FORE AND AFT LEVEL GAUGE
14. TRANSVERSE LEVEL GAUGE
15. PRIMER


Static tube
Laminated balsa wing tip
Round-wood nose spar
C
D
Trailing edge-Aluminum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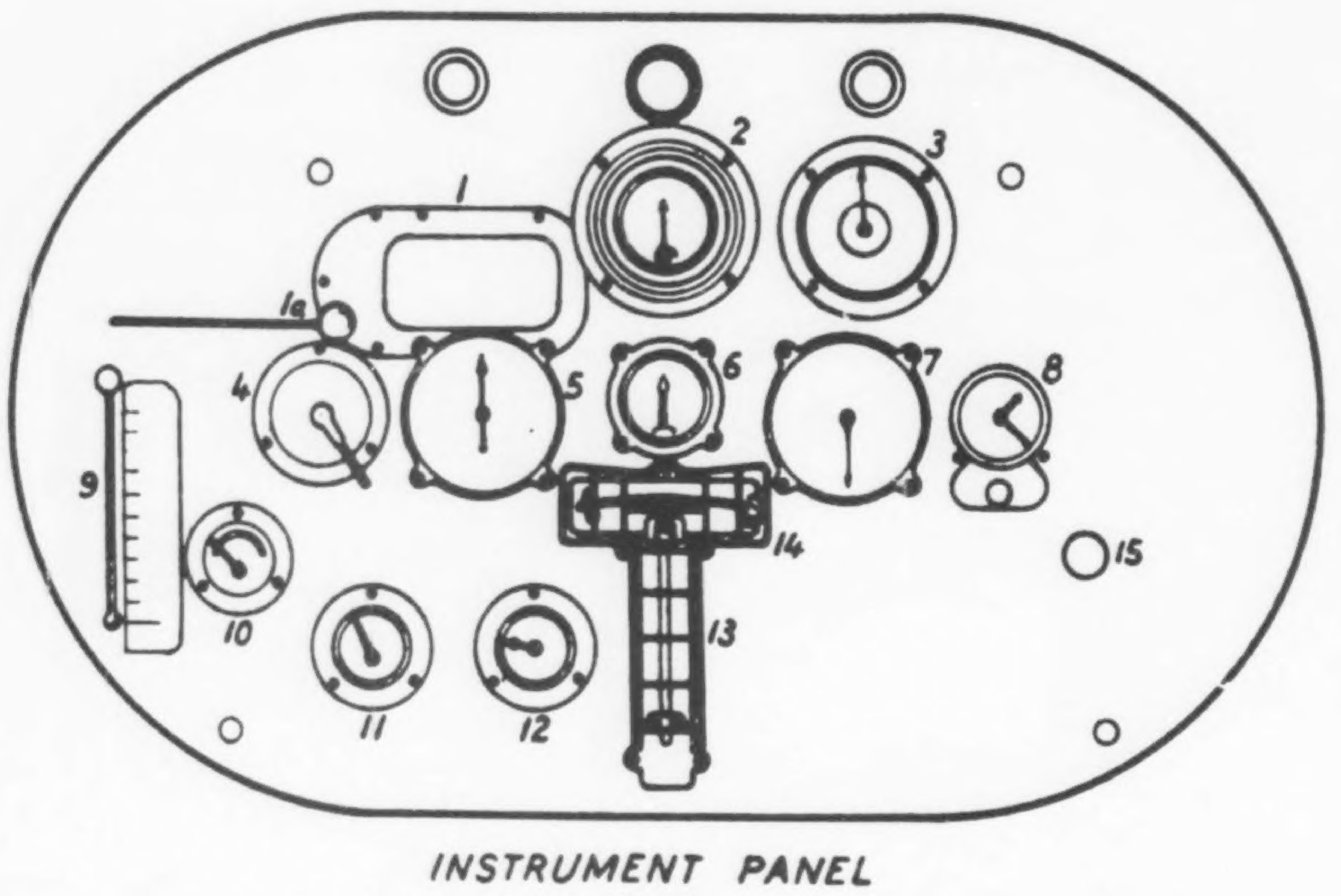
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INSTRUMENT PANEL

Scale

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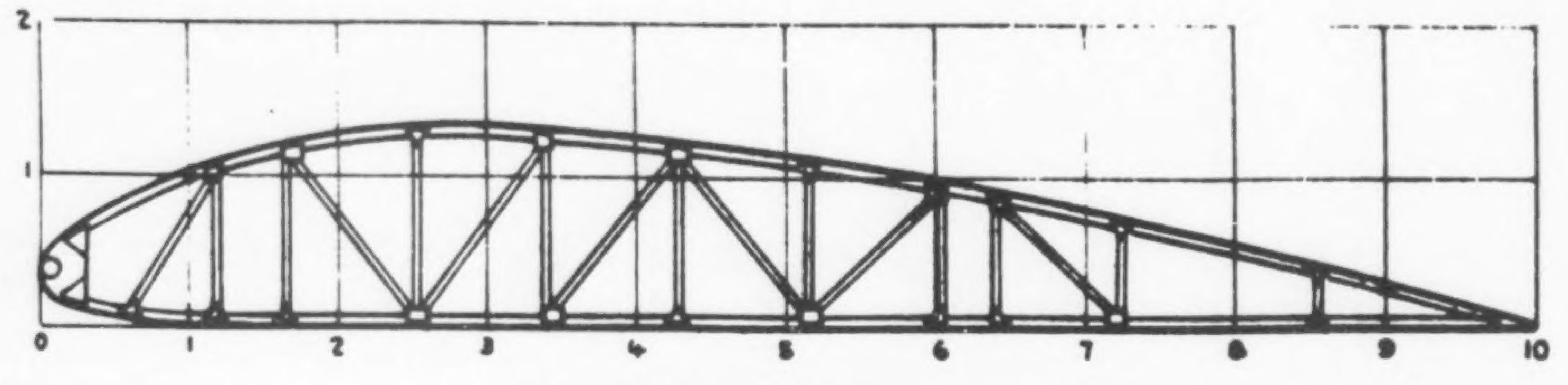
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CLARK "Y" AIRFOIL

Scale

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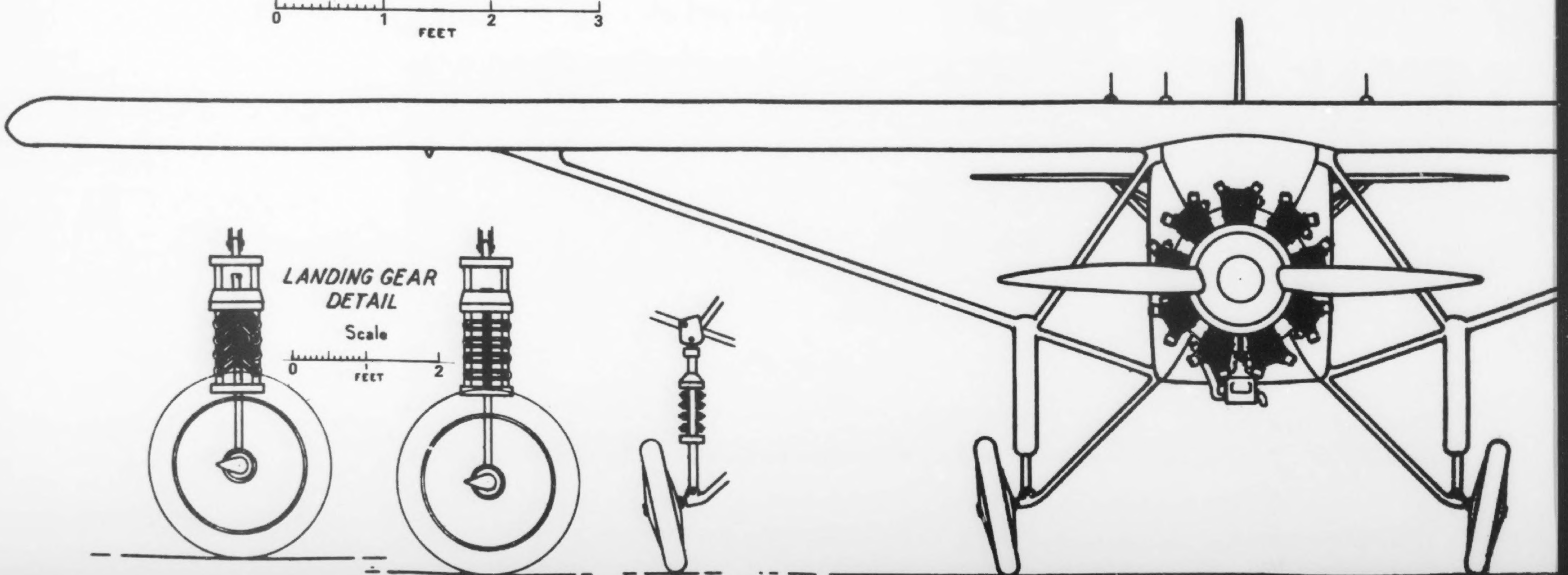
LANDING GEAR DETAIL
Scale
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☐ Teacher
☐ Staff member, educational organization (professional society, non-profit group, or business)
☐ Editor, writer
☐ Other

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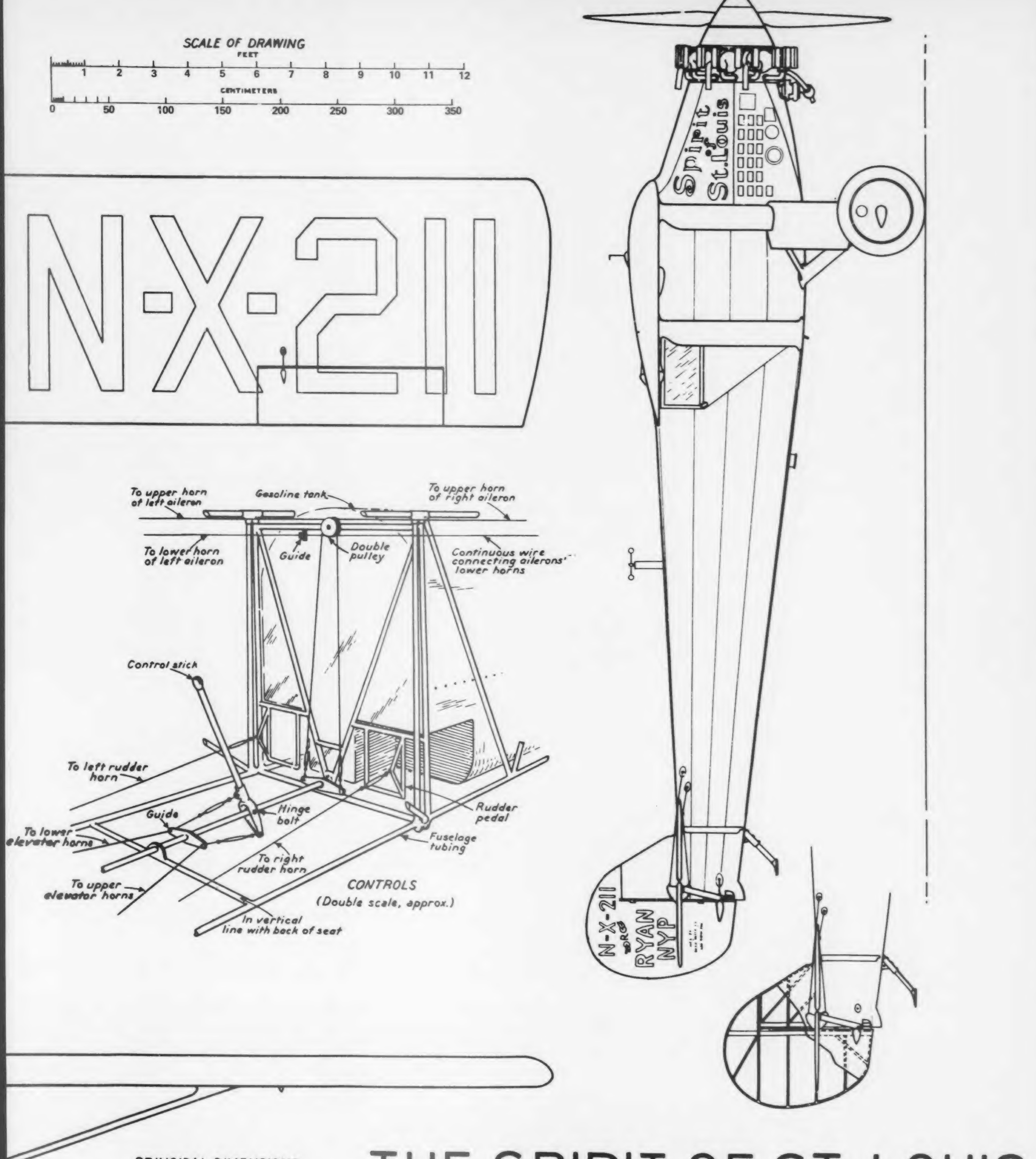

SCALE OF DRAWING
FEET
1 2 3 4 5 6 7 8 9 10 11 12
CENTIMETERS
0 50 100 150 200 250 300 350
N-X-211
Spirit of St. Louis
To upper horn of left aileron
Gasoline tank
To upper horn of right aileron
To lower horn of left aileron
Guide
Double pulley
Continuous wire connecting ailerons' lower horns
Control stick
To left rudder horn
Guide
Hinge bolt
Rudder pedal
To lower elevator horns
Fuselage tubing
To right rudder horn
To upper elevator horns
In vertical line with back of seat
N-X-211
RYAN NYP

CONTROLS
(Double scale, approx.)

PRINCIPAL DIMENSIONS

SPAN:	46' 0"
CHORD:	7' 0"
LENGTH:	27' 7"
HEIGHT:	9' 10"
AIRFOIL:	CLARK "Y"
STABILIZER SPAN:	10' 0"
STABILIZER CHORD:	2' 8"
ELEVATOR CHORD:	2' 5"
ENGINE:	WRIGHT WHIRLWIND J-5-C. 223 HP at 1800 RPM
PROPELLER:	HAMILTON STANDARD. 8' 9" Diameter.

THE SPIRIT OF ST. LOUIS

RYAN NYP 1927

SMITHSONIAN INSTITUTION

NATIONAL AIR AND SPACE MUSEUM

Earth's Family—

Children of the Sun, The Solar System

Teaching geography? *A quick review of all planets may give students a new appreciation of the curious, beautiful, watery one underfoot.*

Teaching mythology? *Who were the deities for whom planets were named long ago?*

Teaching history and exploration? *Planetary missions are the most far-reaching of all time. Sophisticated instruments on spacecraft are like human surrogates, going where life cannot yet be sustained, and to distances almost beyond comprehension.*

Teaching psychology? *What is the effect of realizing that life apparently occurs on only one planet in this solar system, yet may occur elsewhere in the universe, since billions of suns probably also are surrounded by a planetary family.*

Early sky-watchers realized that a few points of light did not maintain a constant relationship with all the others, and so named them "wanderers." (The Greek word for wanderer is the root of the English word "planet.") Efforts to explain their motions resulted in sheer frustration as long as astronomers went along with the conviction of their day that Earth had to be the center of the cosmos. Giordano Bruno died in flames at the stake, in 1600, for the "heresy" of believing otherwise.

Another Italian, Galilei Galileo, adapted lenses made by Dutch opticians to build a telescope and began observations in the winter of 1609-1610. Soon, the truth about planets became accepted—that they all, including Earth, revolve around the Sun as though, for the most part, rolling on a flat disk, the plane of the ecliptic. New members of the Sun's family kept being discovered until the lineup today is, from the Sun out: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and little Pluto, just found in 1931. There may be a tenth, if experts can decide how big a body has to be to justify the name "planet" (see story, Page 13).

Planets took shape from one huge solar nebula, perhaps 4.6 billion years ago. Much has been learned about them from observations where the skies are clearest, but still, Earth's atmosphere is a veil.

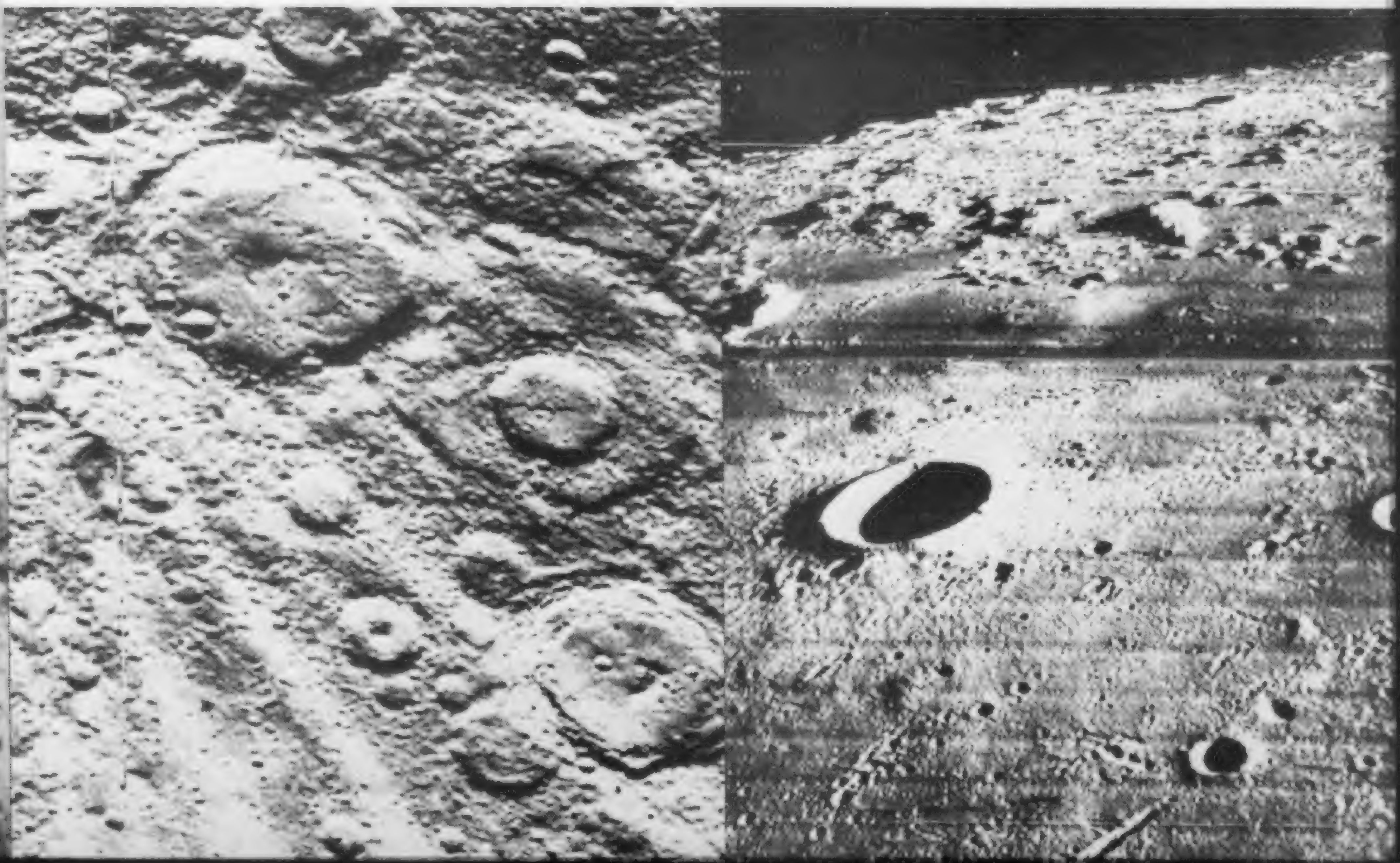
When spacecraft are sent out to fly by or even land, their cameras and sensors radio first-hand information and a new era of fact opens. Spacecraft now orbit the Sun for data on its flood of radiations in which all planets are bathed. Spacecraft have approached Mercury, Venus and Jupiter; Pioneer 11 reaches Saturn in September 1979. Two Soviet landers briefly survived the inferno on the surface of Venus. Six times, U.S. landers put astronauts on the surface of the

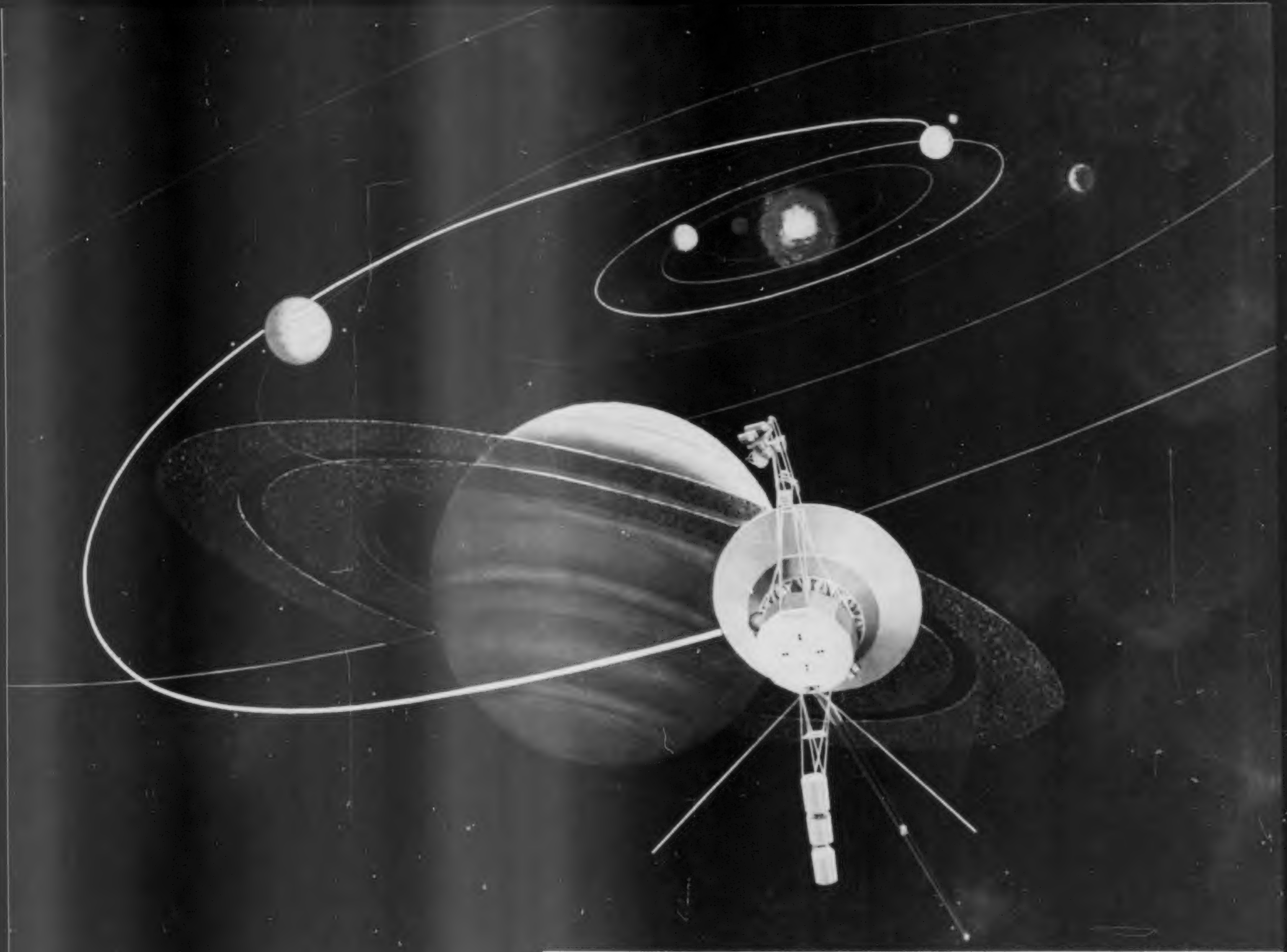
Continued on Page 12

Below, making a mosaic of the Moon in 1968 from 127 photos by Lunar Orbiter IV.

Mercury . . . and the Moon

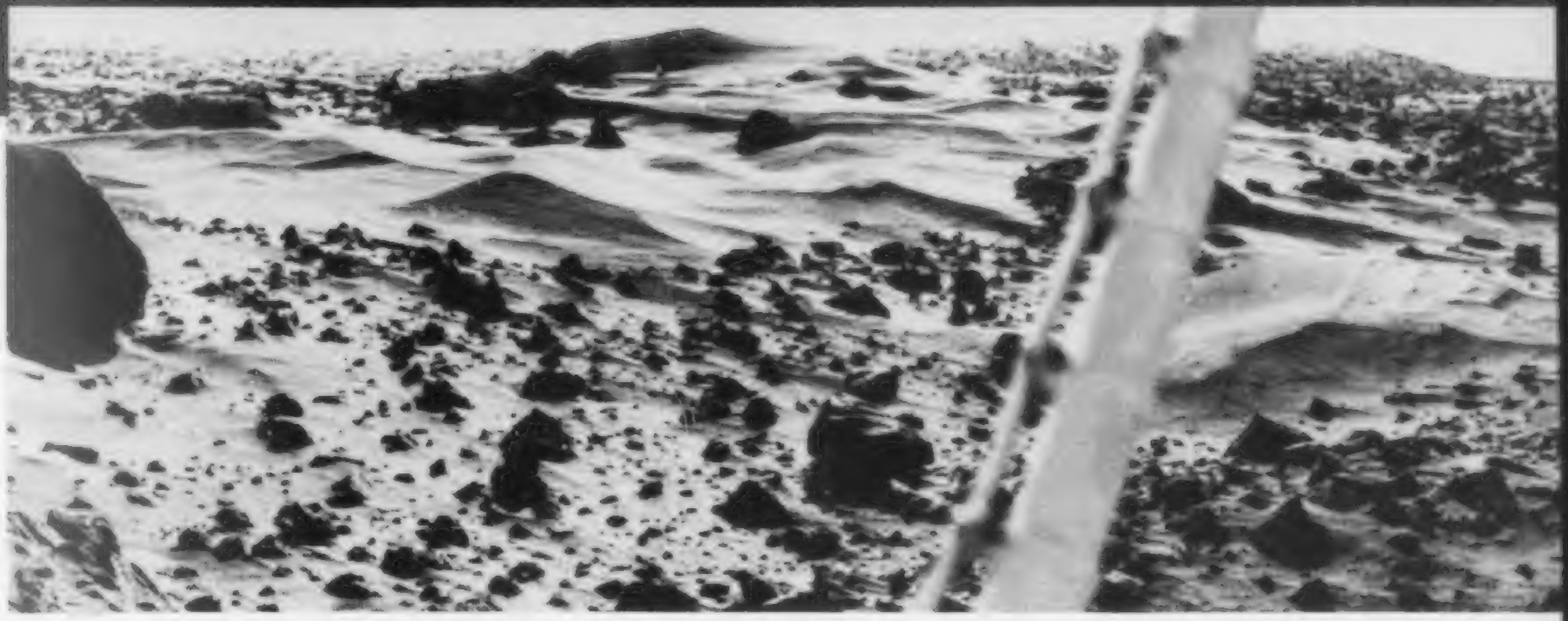
Both are airless and cloudless; with solid cratered surfaces, inactive for eons.





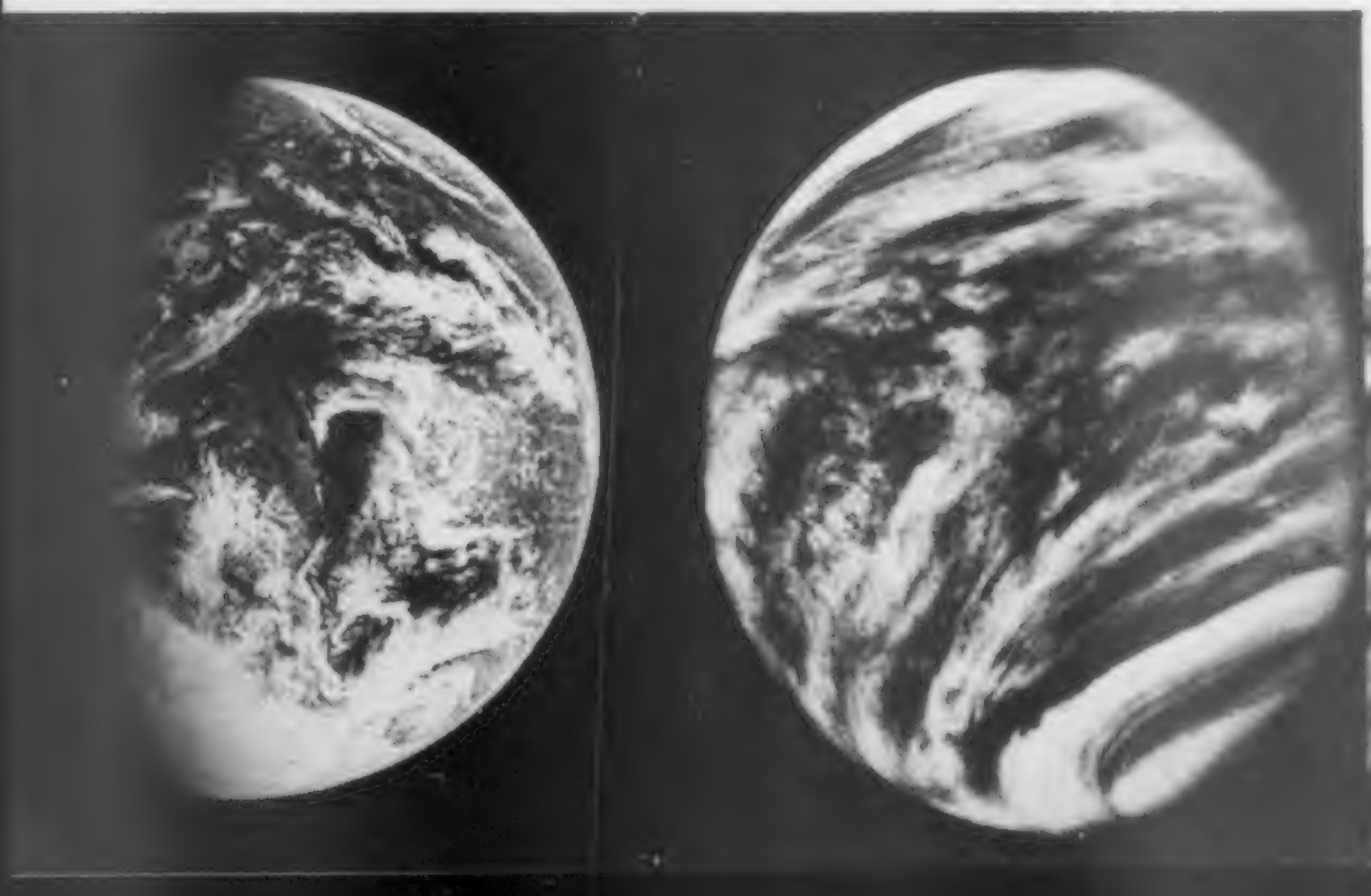
Voyager

In the painting above, one of the two Voyager spacecraft circles Saturn, in 1980, after a 38-month trip from Earth. The trajectory (heaviest white arc) has led past Jupiter. Mercury and Mars are faint, Venus brighter.



Earth . . . and Venus

Clouds here: water vapor, variable; on Venus: sulfur and sulfuric acid, total cover. Temperature there: 900°F. everywhere; pressure 100 times Earth's.

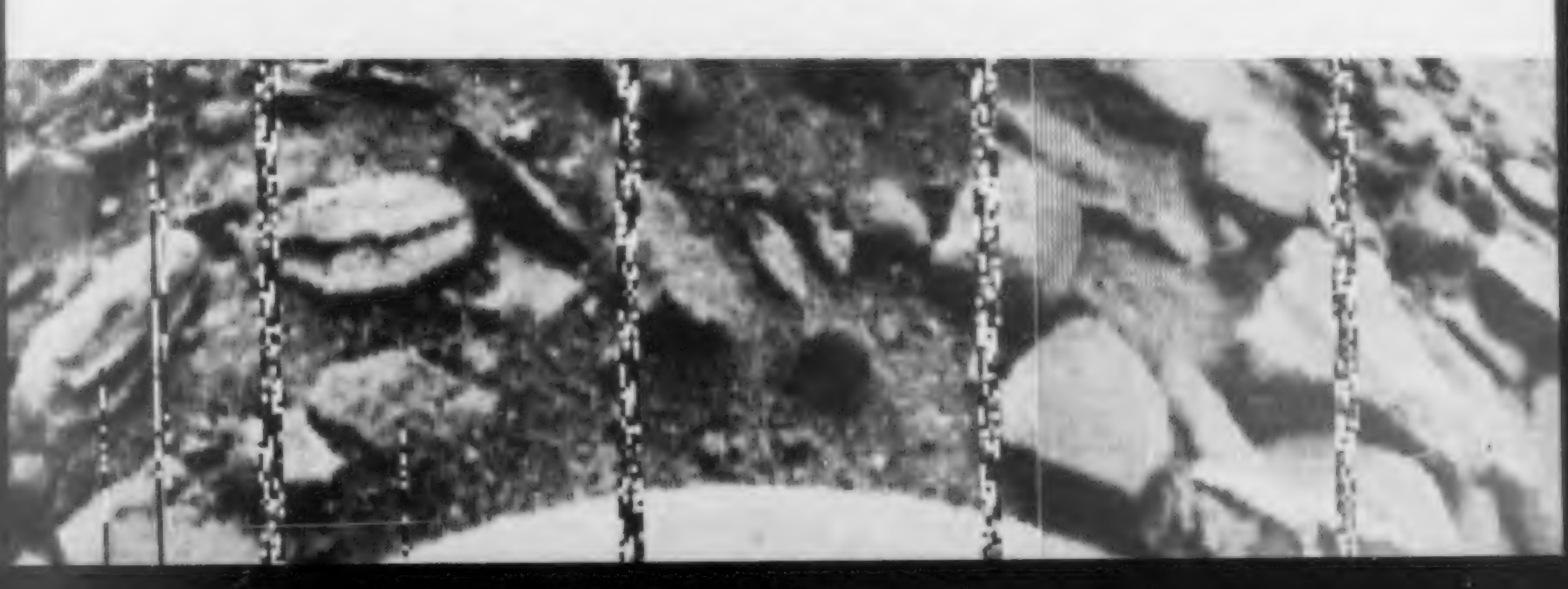


The Surface of Mars

Sand dunes and rocks near the Viking 1 lander. Elsewhere: huge volcanoes and rifts, and unexplained channels like dry river beds on Earth.

The Surface of Venus

One of two pictures obtained by Soviet landers; angular rocks show little erosion. Radar mapping indicates a comparatively smooth surface.



THE SOLAR SYSTEM—

Continued from Page 10

Moon; the men brought back a total of 382 kilograms (843 pounds) of the surface for analysis here. The two Viking landers have been at work on Mars since mid-1976. One of the two Voyager spacecraft now on their way to Jupiter and Saturn may continue to Uranus and arrive in 1986.

Thus, planets are no longer just twinkling lights.

To millions of people who read about space missions, they are now real worlds of deserts and rock fields, cratered plains and mountains . . . places which the human adventurer could conceivably visit in the future, when life support and protection systems are improved.

Although Earth's siblings have chemical elements in common, the variety of manifestation is astonishing. The four inner planets have hard, rocky surfaces. The big outer ones may be only globes of gas with no specific surface. Some have atmospheres; others don't. Some have magnetic fields; others don't. Mercury shouldn't have a magnetic field, it was thought, but the Mariner 10 spacecraft found one. The chemistry of Mars is a puzzle. When surface samples were tested inside the two Viking landers, some reactions indicated that organisms were metabolizing nutrients, yet other evidence for life is lacking. Radiations around Jupiter are as intense as those inside a nuclear reactor. And so it goes, in this era of the most far-flung exploration of all time . . . one surprise after another, all illuminating the history of this planet, and what might happen in the future. Could air pollution create a "greenhouse effect" like that which suffocates Venus? Mars apparently had great rivers at one time; why did they dry up?

Such questions are the concern of the National Air and Space Museum's Center for Earth and Planetary Studies, under Dr. Farouk El-Baz. Work by the staff of geologists will be reflected in future issues of *Air & Space*.

On Planets and the Universe

Scientific American, September 1975, an entire issue on the Solar System.

The Inner Planets, C. R. Chapman, 170 pp., illus. Chas. Scribner's Sons, New York, 1977, $7.95.

What's New on the Moon? Bevan M. French, 24 pp., illus., NASA EP-131, Government Printing Office, Washington, DC 20402, Stock No. 033-000-00653-5, $0.70 (minimum mail order, $1.00).

Various scientific studies, Lunar Science Institute (Library), 3303 NASA Road 1, Houston, Texas 77058.

The Moon: Steppingstone to Outer Space, D. E. Shuttlesworth and L. A. Williams, 117 pp., illus., Doubleday, New York, 1977, $5.95. For younger readers.

Mars, the Viking Discoveries, Bevan M. French, 32 pp., illus., NASA EP-146, Government Printing Office, Washington, DC 20402, 1977, Stock No. 033-000-00703-5, $1.50.

On *Jupiter*, various leaflets and pictures from NASA Ames Research Center, Educational Services, Mountain View, California 94035, free.

Four teaching supplements on the most recent methods and findings of astronomy were prepared by the American Astronomical Society in cooperation with NASA and the National Science Foundation, with 42 teachers and 6 astronomers as curriculum and science advisers. All books, published in 1976, are 8 by 10½ inches, illustrated, with glossaries, extensive references and class projects; and may be ordered from Government Printing Office, Washington, DC 20402.

The Supernova, NASA EP-126, 37 pp., Stock No. 033-000-00654-3, $1.30.

Chemistry Between the Stars, NASA EP-127, 59 pp., Stock No. 033-000-00655-1, $1.60.

Atoms and Astronomy, NASA EP-128, 31 pp., Stock No. 033-000-00656-0, $1.20.

Extragalactic Astronomy, NASA EP-129, 38 pp., Stock No. 033-000-00657-8, $1.30.

How to Witness Pioneer-Venus Events

Readers can make arrangements with NASA's Ames Research Center to watch the launches of the next two planetary missions (Pioneer Venus-A and B) from inside Kennedy Space Center; and later at Ames, share mission controllers' views as the spacecraft encounter Venus. Although launched May 20 and August 7, both Pioneers will arrive at the same time, in the December 10-12 period of the Ames conference. Those attending will see the TV pictures and hear NASA scientists explain data as they come in from Venus. Ames is at Moffett Field, Mountain View, California. Dates are subject to change.

Two colleges near Ames are cooperating with bookings for National Airlines affinity charter flights between California and Florida. They also offer lectures on the Venus mission. Persons elsewhere in the nation may register with Ames for entry to the reserved viewing area at Kennedy Space Center. They would make their own travel arrangements and motel reservations. A list of convenient motels and full information are available from the organizer of the events, Garth Hull, Educational Programs Officer, NASA Ames Research Center, Mountain View, California 94035, telephone 415/965-5543.

The college coordinators are: Richard Rodgers, Physics Department, College of Marin, Kentfield, California 94904, telephone 415/485-9510; and Lee Bonneau, Foothill Community College, 12345 S. El Monte Avenue, Los Altos, California 94022, telephone 415/948-8590, Ext. 391.

Other Launches

Other summertime launches from Kennedy Space Center are:

June–GEOS-B, a scientific satellite from the European Space Agency, to study radiations in geosynchronous orbit (called GEOS-2 after a successful launch).

July–ISEE-C, International Sun-Earth Explorer, to record solar radiation at a Lagrange libration point, for comparisons with data from ISEE-1 and 2 in other orbits.

For information on exact dates of launch, write to Public Information, Kennedy Space Center, Code PA-PIB, Florida 32899; or telephone 305/867-2468.

Did Astronomer Kowal Find Another Planet?

by Courtland Lewis
Carnegie Institution of Washington

As modern astronomy has gained the use of sophisticated electronics techniques for enhancing the effective reach of big telescopes, it has become possible to systematically map distant areas in our Galaxy and beyond. Naturally our own Solar System is by now considered pretty familiar territory, populated only by the Sun, the nine planets with their moons, a sprinkling of asteroids in orbit between Mars and Jupiter, and the occasional wayward comet.

So it came as a surprise when astronomer Charles Kowal of the Hale Observatories discovered recently what some astronomers thought at first might be the tenth and smallest planet in the Solar System. Because astronomers were not sure how to classify it, the body was initially given the neutral designation "Object-Kowal." Just recently Mr. Kowal assigned it a permanent name: Chiron, for one of the centaurs in Greek mythology.

On November 1 Mr. Kowal was using a "blink microscope" to compare two photographic plates taken October 18 and 19 through the 48-inch Schmidt telescope at Palomar. Since the plates covered the same area of the sky and since the telescope tracked with the movement of the star-field, anything that was not a star would be in a different place on each plate relative to the star background. Kowal spotted the movement of a single tiny point. Two other astronomers soon confirmed the existence of the object on their own photographs of the area. Since then, it has been discerned on photographic plates dating back to 1895, an indication of how easily such small objects can escape detection.

Kowal has readily admitted, "I haven't the slightest idea what it is." Chiron follows a fairly eccentric path from inside the orbit of Saturn out to that of Uranus, at a distance of around 1½ billion miles from Earth (the mythological Chiron was a descendant of the gods Saturn and Uranus). The plane of its orbit coincides within about 7 degrees with that of the other planets, which—along with the fact that its image is sharp, not hazy—means that it is not a comet. But unlike the planets, Chiron seems to have an unstable orbit; that is, it changes slowly over a long period of time.

By calculating its apparent brightness against its distance, Kowal determined that his object has a diameter of from 100 to 400 miles, depending on its composition. If its surface is dark, like that of a carbonaceous chondrite meteorite, the size must be greater than if it is made of a highly reflective, icy material.

This places the body in the size range of the larger asteroids. It has not been classified as an asteroid chiefly because all known asteroids, no matter how unusual in their orbital characteristics, at some point cross the asteroid belt inside Jupiter. But Kowal and his fellow astronomers do not rule out the possibility that there might be a trans-Saturnian asteroid belt, with Chiron being the first discovered. Since it is the first object—asteroid or planet—to bear the name of a centaur, other bodies discovered in such a new belt might all be given the names of centaurs, which would provide a convenient way of identifying them as a group.

If the object turns out to be a solitary specimen, it would represent something generically new in the Solar System, an object like the other planets in everything but size and stability of orbit. The smallest planet, Mercury, has a diameter of 3100 miles, ten times as large; but there is no established minimum size for a planet. It is just that the planetary formation processes make it unlikely that bodies much smaller than Mercury will form singly in planetary orbit. Nevertheless, Kowal was for a time calling his object a "mini-planet," something like the 19th-century term "planetoid." Just recently some astronomers have speculated that it is an errant asteroid knocked out of the main belt by a collision; others wonder if it might be a "cold" comet too distant from the sun to become ionized and glow. Whatever it turns out to be, Chiron may prompt astronomers to formulate a standard definition of "planet."

Charles Kowal is unusual among contemporary astronomers in having only a bachelor's degree. He has been working at Hale Observatories ever since graduating from USC in 1961 at the age of twenty. Kowal is credited with discovering more than 80 supernovae, one new comet and several that had gotten "lost," and the thirteenth and probable fourteenth moons of Jupiter.

Reprinted by permission from the Carnegie Institution Newsletter, Feb. 1978.

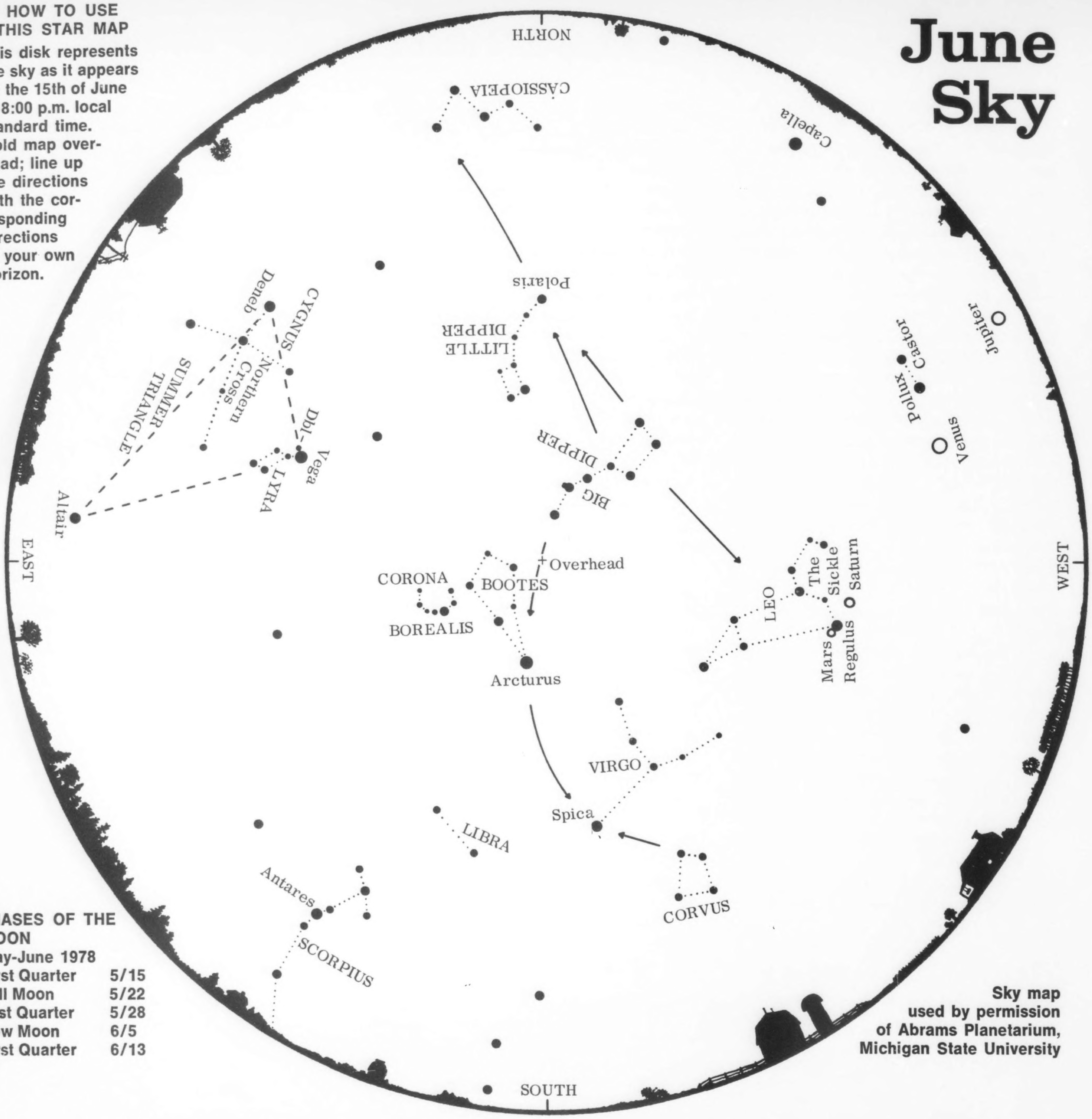
The Shuttle Orbiter *Enterprise* rode its Boeing 747 carrier into NASA's Marshall Space Flight Center, Alabama, last March, for months of ground vibration tests with fuel tanks to simulate the stresses of launch.

Left, Greg Kennedy of the Museum's astronautics staff, with model of the duo he made for exhibition.

June Sky

HOW TO USE THIS STAR MAP

This disk represents the sky as it appears on the 15th of June at 8:00 p.m. local standard time. Hold map overhead; line up the directions with the corresponding directions of your own horizon.


NORTH
CASSIOPEIA
Capella
Polaris
LITTLE DIPPER
Jupiter
Castor
Pollux
Venus
CYGNUS
Deneb
Northern Cross
SUMMER TRIANGLE
Dbl-
Vega
LYRA
Altair
BIG DIPPER
EAST
WEST
Overhead
CORONA BOREALIS
BOOTES
Arcturus
LEO
The Sickle
Saturn
Mars
Regulus
VIRGO
Spica
LIBRA
Antares
SCORPIUS
CORVUS
SOUTH

PHASES OF THE MOON
May-June 1978

First Quarter	**5/15**
Full Moon	**5/22**
Last Quarter	**5/28**
New Moon	**6/5**
First Quarter	**6/13**

Sky map used by permission of Abrams Planetarium, Michigan State University

by Dennis Mammana
Planetarium Production Specialist
National Air and Space Museum

On warm spring and summer evenings, we can use the Big Dipper to help us locate four prominent stars and constellations. Follow the "pointer" stars in the Big Dipper's bowl, from the bottom to the top of the bowl, until this imaginary line intersects Polaris, the North Star. Polaris is located at the end of the handle of the Little Dipper. If we follow the "pointer" stars in the opposite direction we fall directly into the belly of Leo the Lion. The head of Leo is formed by a backward question mark of stars that is dotted by the bright star Regulus. Let us now find two other prominent stars by using the curved handle of the Big Dipper. We can follow its "arc" to Arcturus, and then "speed on" to Spica. Arcturus and Spica are the brightest stars in the constellations of Bootes and Virgo, respectively.

Also located in the current evening sky are four planets. Very near the northwest horizon shortly after sundown is Jupiter, accompanied by the most brilliant planet, Venus. Watch during the coming weeks as Venus drifts slowly eastward past Jupiter and into the constellation Gemini. These two planets will make a beautiful pair at dusk. Midway up the western sky in the early evenings lie two more worlds, Mars and Saturn. During May, Mars will drift eastward through the stars, approaching Saturn until, in early June, the two will appear to be almost touching. At that time they will lie in Leo, very near Regulus. A small telescope will make this planetary conjunction appear even more spectacular since surface features on the planets and the rings of Saturn will be plainly visible. To even the casual naked-eye observer at this time, the orange color of Mars and the yellow of Saturn should contrast sharply with the white star Regulus.

During the Moon's monthly trek across the sky, it will appear to pass several objects. Look for the Moon to pass south of Jupiter on June 7, Venus on June 8, Mars on May 14 and June 11, and Saturn on May 15 and June 11.

New Curriculum Plans

A new handbook, *Elementary School Aerospace Activities,* offers curriculum outlines and projects prepared at The University of Nebraska-Lincoln. These cover ten areas, as Earth Characteristics that Affect Flight, Technological Advances, Unmanned Earth Satellites and Unmanned Exploration of the Solar System, Life-Support Systems, etc. Explicit drawings show how students can make objects to illustrate scientific basics. Extensive references include sources of audio-visual as well as printed material. Paperback, 8 by 10 in., 127 pp., illus. NASA EP-147, 1977. Government Printing Office, Washington, DC 20402, Stock No. 033-000-00693-4, $3.00.

New Spacecraft Chart

A colorful poster, 24 by 36 inches, combines artists' drawings of some three dozen spacecraft and uses for Shuttle Orbiters which have been proposed for the years 1980-2000. Called "era of space transportation," the poster is sent at no cost on request to Editor, HORIZONS, B25-05, Grumman Aerospace Corp., Bethpage, New York 11714.

Sources of Aviation Literature

The following regional FAA offices send educational materials on request:

For residents of Alaska:
Asst.Public Affairs Officer, AAL-5
Federal Aviation Administration
632 Sixth Avenue
Anchorage, Alaska 95501

For residents of Nebraska, Iowa, Kansas and Missouri:
Planning/Appraisal Specialist, ACE-4
Federal Aviation Administration
601 East 12th Street
Kansas City, Missouri 64106

For residents of New York, Maryland, New Jersey, Virginia, Delaware, Pennsylvania, West Virginia and Washington, DC:
Emergency Plans Officer, AEA-4
Federal Aviation Administration
JFK International Airport
Jamaica, New York 11430

For residents of Illinois, Michigan, Indiana, Minnesota, Ohio and Wisconsin:
Aviation Education Specialist, AGL-4.6
Federal Aviation Administration
2300 East Devon Ave.
Des Plaines, Illinois 60010

For residents of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont:
Public Affairs Officer, ANE-5
Federal Aviation Administration
12 New England Executive Park
Burlington, Massachusetts 01803

For residents of Oregon, Washington state and Idaho:
Public Affairs Officer, ANW-5
Federal Aviation Administration
Boeing Field
Seattle, Washington 98108

For residents of Hawaii, Wake, Samoa, Guam:
Public Affairs Officer, APC-5
Federal Aviation Administration
P. O. Bov 4009
Honolulu, Hawaii 96812

For residents of Colorado, Montana, Wyoming, Utah, North and South Dakota:
Aviation Education Specialist, ARM-4
Federal Aviation Administration
10455 East 25th Avenue
Aurora, Colorado 80010

For residents of Tennessee, Alabama, North and South Carolina, Mississippi, Florida, Kentucky, Georgia and Puerto Rico:
Public Affairs Officer, ASO-5
Federal Aviation Administration
P. O. Box 20636
Atlanta, Georgia 30320

For residents of Arkansas, Louisiana, New Mexico, Oklahoma and Texas:
Aviation Education Coordinator, ASW-5
Federal Aviation Administration
P. O. Box 1689
Ft. Worth, Texas 76101

For residents of California, Nevada, Arizona:
Public Affairs Officer, AWE-5
Federal Aviation Administration
P. O. Box 92007
World Way Postal Center
Los Angeles, California 90009

Industrial Arts — A Call for Help

I just received the March issue of *Air & Space* . . . found it very helpful with our program development. I have completely restructured our Industrial Arts Program to include the six divisions of: Communications, Construction, Management, Manufacturing, Power, and Transportation. In the Transportation unit we are designing and developing units on land, water, air, and space transportation with the goal of exposing the students to the six systems common to all transportation: propulsion, support, guidance, control, suspension, and structure.

As we work toward our goal, I find little has been developed toward instructional materials and student activities. . .

John H. Emmons
City Chairperson, Industrial Arts
Canton City Schools, 1120 15th St. NW
Canton, Ohio 44703

Can any readers send Mr. Emmons helpful material or references?

ILLUSTRATION CREDITS

Cover: Langley Research Center. Page 2: NASM and NASA. Page 3: GAT-1, Richard Hofmeister, NASM; Johnson Space Center; Langley; McDonnell Douglas. Page 4: Langley. Page 5: Diagrams, Lewis Research Center; Langley; Vought Corp. of LTV. Page 6: from *Visual Communications Systems* by William J. Reynolds, CAP. Page 7: NASM; Flyer by North Shore: Sunday Photo. Pages 8-9: NASM. Pages 10-11: NASA. Page 13: Marshall Space Flight Center; Dick Farrar, NASM. Page 16: Concorde, British Aerospace Corp.; schlieren, Dr. James A. Van Allen; painted model, Vought Corp.

Educators — Please tell *Air & Space* what kinds of material are most valuable. Check interests below and mail form to Room 3569, National Air and Space Museum, Washington, DC 20560.

HISTORY: Aspects of aviation ☐; space programs ☐. TODAY: Civilian aviation ☐; space programs ☐;

THE FUTURE: Aviation ☐; space ☐.

PRINCIPLES of flight: air ☐; space ☐. PROPULSION ☐.

SCIENTIFIC studies from air and spacecraft: Earth's surface ☐; atmosphere/climate ☐;
Sun/Earth ☐; planets ☐; astronomy ☐.

EARTH SERVICES: mapping/monitoring ☐; communications ☐; weather ☐.

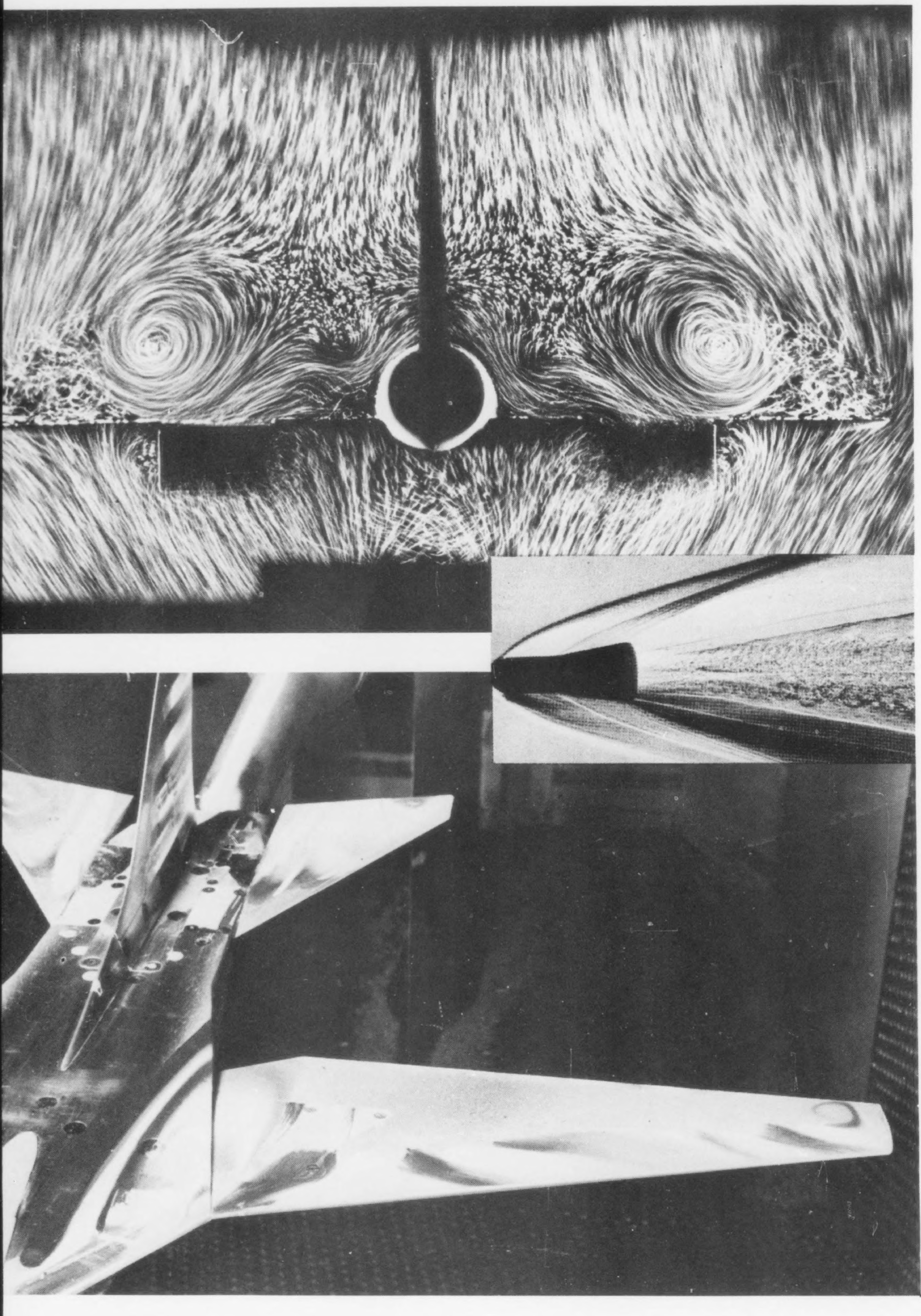
INTERNATIONAL links (manufacturing, regulation, science) ☐. Competition/Soviet programs ☐.

HOW STUDENTS may participate in aviation ☐; in space operations ☐.

PROPOSALS: Space industry ☐; space "colonies" ☐; search for extraterrestrial intelligence ☐.

MORE visual material ☐. More references ☐. OTHER: ____________________________

THINK ALONG WITH THE AEROSPACE ENGINEERS



on visualizing airflow:

Any method is fine, if it works.

Air is a fluid; so is water, but more viscous, useful only for slow speed testing. At top left is an image from "le tunnel hydrodynamique" near Paris. A model of the British-French Concorde reveals flow patterns just before touchdown. Huge vortices over the delta wings are evident.

Shock waves can be photographed through the schlieren optical system (center, left).

Wet paint on the leading edges of a model will smear according to the air flow in a wind tunnel (lower left). Liquid charcoal can be used similarly. This model in the Vought Corporation's wind tunnel was fitted with strain gages (the little insets). Generally, strain gages can be used to measure things like the distribution of forces on a model or the way an aero-structural model bends and twists under realistic flight conditions.

Tufts of threads fixed over an entire model bend like grass in the wind to show how air is moving. Smoke has limited use; fog is denser, lasts longer, and works in supersonic wind tunnel testing. McDonnell Douglas technicians make a fog by adding cold nitrogen to steam; when the gas is blown through a supersonic nozzle, temperature drops and fog forms.

What other flow visualization techniques can students propose?

NATIONAL AIR AND SPACE MUSEUM
THE SMITHSONIAN INSTITUTION
WASHINGTON, DC 20560

Michael Collins, Director
Melvin B. Zisfein, Deputy Director
Lynne C. Murphy, Public Relations

Julie Forbush, Editor, *Air & Space*

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The Director of the Museum invites suggestions for making *Air & Space* as useful as possible. Some letters may be published; writers should indicate if they prefer that their names not be used.

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